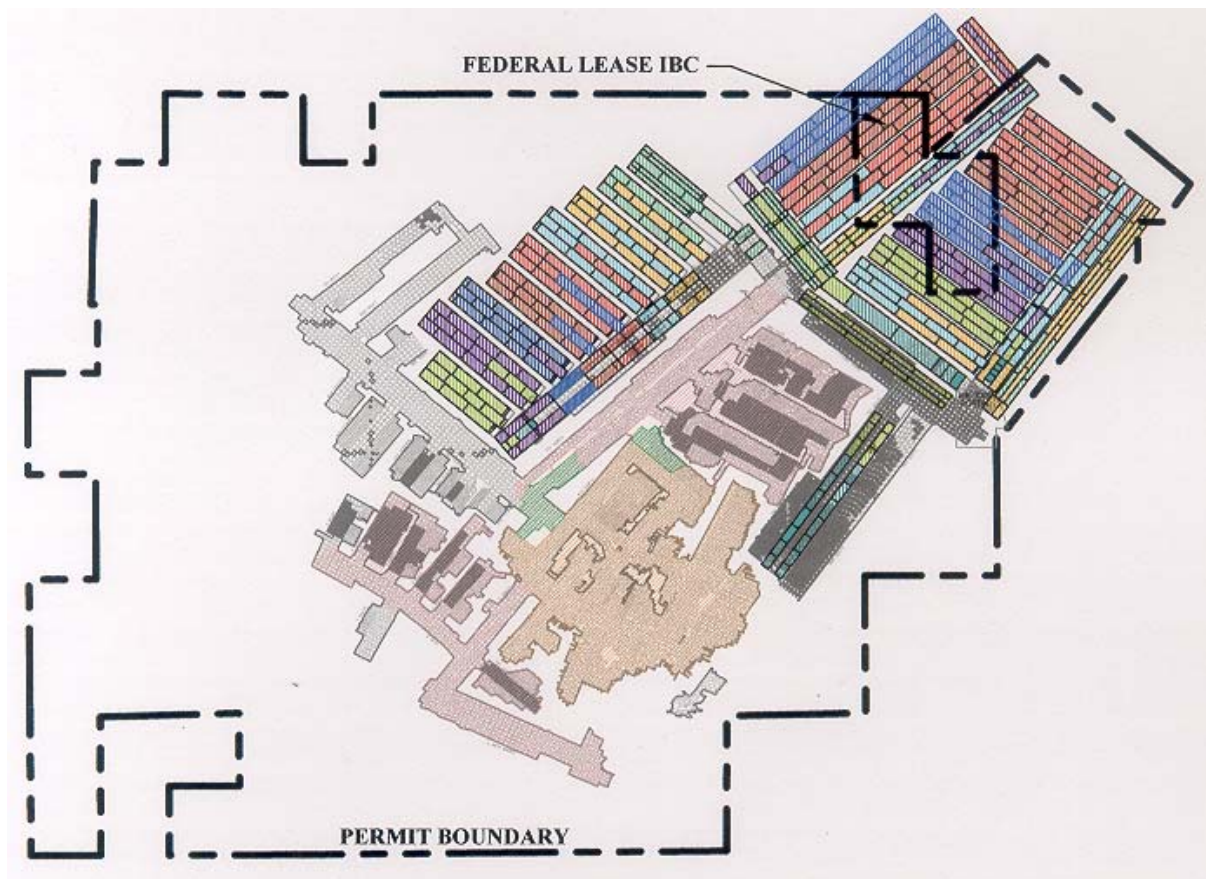


# CONSOLIDATION COAL COMPANY EMERY MINE

PERMIT ACT/015/015

## CHAPTER XIII

### FEDERAL LEASE AREA INCIDENTAL BOUNDARY CHANGE APPLICATION



**CHAPTER XIII**

**EMERY MINE FEDERAL LEASE  
INCIDENTAL BOUNDARY CHANGE  
APPLICATION**

EMERY MINE  
CONSOLIDATION COAL COMPANY  
EMERY COUNTY, UTAH

SUBMITTED TO

UTAH DIVISION OF OIL, GAS AND MINING

PREPARED BY

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SEPTEMBER 12, 2006

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## **CHAPTER XIII**

### **EMERY MINE FEDERAL LEASE INCIDENTAL BOUNDARY CHANGE APPLICATION**

#### **XIII.A INTRODUCTION**

This application for an incidental boundary change ("IBC") is submitted to the Utah Division of Oil, Gas and Mining ("UDOGM") by Consolidation Coal Company ("Consol") for the Emery Mine in Emery County Utah (UDOGM Permit No. ACT/015/015). The IBC area encompasses approximately 160 acres of private land and Federal coal adjacent to the northeast portion of the existing Emery Mine permit area (see Plate I-1 of the approved MRP). The IBC falls within the area of an existing Cumulative Hydrologic Impact Assessment and is within a drainage basin already authorized in the approved mining and reclamation plan ("MRP").

Approval of this IBC request will allow Consol to develop additional coal reserves in the northern portion of the permit area without the need for new surface disturbances. Coal will be extracted under this application from the IJ zone of the Ferron Sandstone using room and pillar methods without pillar extraction (i.e., first mining only).

#### **XIII.B GENERAL CONTENTS**

##### **XIII.B.1 RIGHT OF ENTRY**

The U.S. Government is the owner and Consol is the leaseholder (Lease No. U-50044) of all coal to be mined under this IBC application (see Plate I-1 of the approved MRP). Information regarding coal ownership within the IBC and adjacent areas is provided in Chapter I of the approved MRP.

All of the Federal Lease IBC surface land is owned by D.U. Company Inc. (see Plate I-1). Information regarding surface ownership within the IBC and adjacent areas is provided in Chapter I of the approved MRP. Consol knows of no pending litigation concerning their right to mine coal within the IBC area.

##### **XIII.B.2 LEGAL DESCRIPTION AND STATUS OF UNSUITABILITY CLAIMS**

The area affected by this IBC application is located in SW~~3~~NW~~3~~, NW~~3~~SW~~3~~, NE~~3~~SW~~3~~, and SE~~3~~SW~~3~~ of Section 22, T. 22 S., R. 6 E., SLBM. Consol knows of no portion of the Federal Lease IBC that is designated, or under study to be designated, as unsuitable for mining. Consol does not propose to conduct coal mining or reclamation operations in the IBC area within 300 feet of any occupied dwelling or within 100 feet of a public road.

### **XIII.C ENVIRONMENTAL RESOURCE INFORMATION**

#### **XIII.C.1 PERMIT AREA**

The lands subject to coal mining operations within the IBC area are noted on Plate I-1. It is not anticipated that individual permits will be sought for subareas within the IBC area. A discussion of cultural resources within the IBC area is provided in Appendix XII-3 of the approved MRP. This prior Class I survey, conducted in May 2005, included all of the area of the Federal Lease IBC and identified no cultural resources within that area.

#### **XIII.C.2 SOIL RESOURCE INFORMATION**

Soil resources in the IBC area are depicted in Figure XIII-1. Descriptions of these soils are provided in Appendix XIII-1. Soil series descriptions in the appendix were obtained from the U.S. Natural Resources Conservation Service (2006). Descriptions of individual map units were obtained from Swenson et al. (1970). Soils within the IBC area tend to be fine grained, ranging generally from loam to silty clay loam. If irrigated, the soil supports alfalfa and similar crops. Otherwise, the soils mostly support rangeland plants such as shadscale, Indian ricegrass, greasewood, and/or saltgrass. Penoyer Loam and Ravola Loam are considered prime farmland when irrigated (Appendix XIII-1). About 2 acres of Penoyer Loam and 10 acres of Ravola Loam are irrigated and, therefore, may be prime farmland within the IBC area. Although subsidence is not planned, ground movement will be monitored in accordance with Section V.B.1 of the MRP.

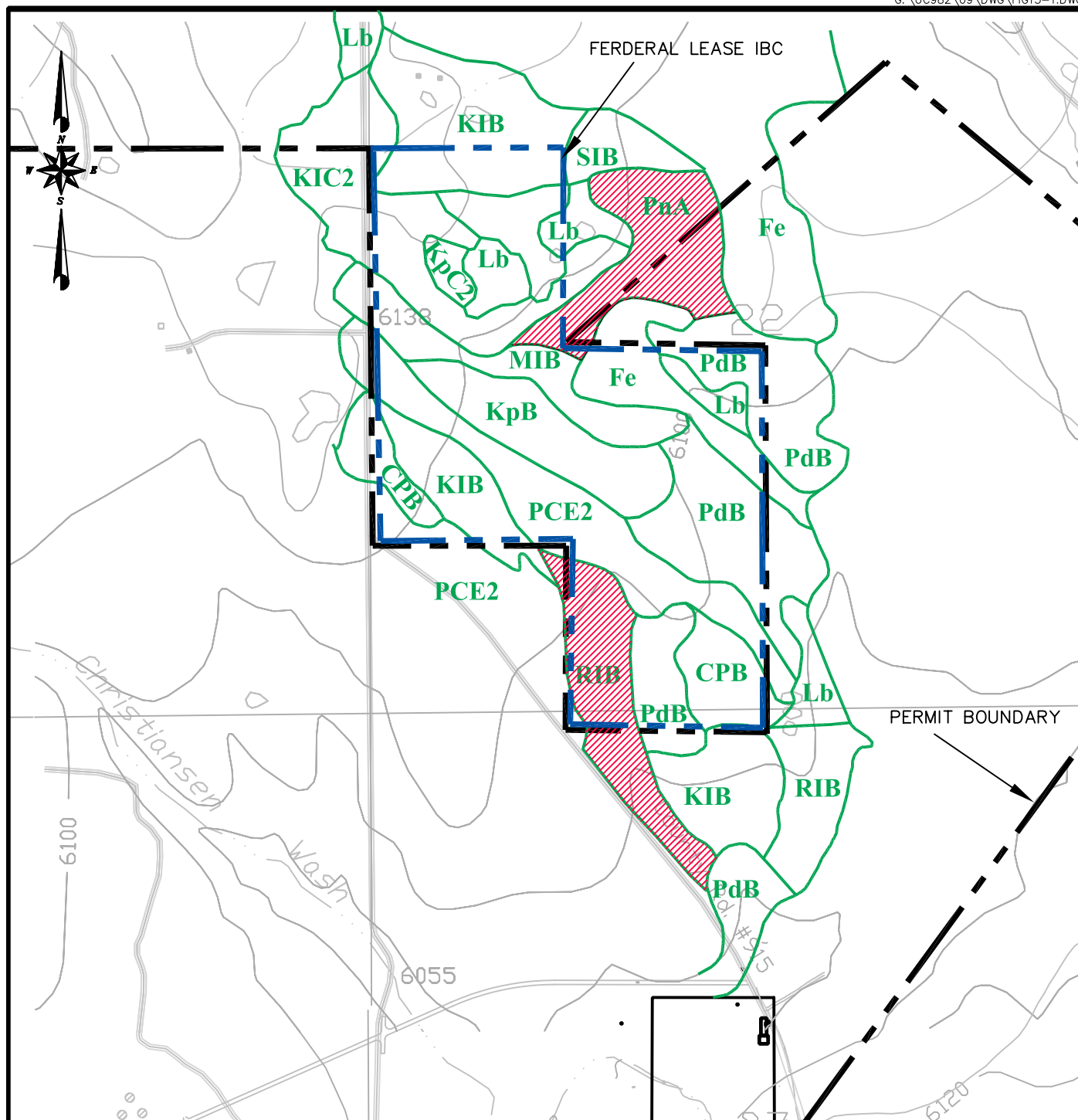
Additional information regarding soil resources in the IBC and adjacent areas is provided in Chapter VII of the approved MRP. Impacts to soil resources are not anticipated as a result of mining under this application since no new surface disturbances are planned.

#### **XIII.C.3 VEGETATION RESOURCE INFORMATION**

Information concerning vegetation resources within the IBC area is provided in Appendix XIII-2. Three plant communities are present in the IBC area, namely greasewood, shadscale/winterfat, and pasture (both irrigated and dry land). Information presented in Appendix XIII-2 indicates that federally-listed threatened or endangered plant species are not likely to exist in the IBC area. No impacts to vegetation are anticipated from mining in the IBC area due to the planned non-disturbance of the surface.

#### **XIII.C.4 FISH AND WILDLIFE RESOURCE INFORMATION**

Information regarding fish and wildlife resources within the IBC and adjacent areas is provided in Appendix XIII-2. Additional information regarding fish and wildlife resources in the IBC and adjacent areas is provided in Chapter IX of the approved MRP. The IBC area is located within a zone of high value winter habitat for elk.



# LEGEND


<b>CPB</b>	CHIPETA-PERSAYO ASSOCIATION, 1 TO 3 PERCENT SLOPES.	<b>PCE2</b>	PERSAYO-CHIPETA ASSOCIATION, 1 TO 20 PERCENT SLOPES, ERODED.
<b>Fe</b>	FERRON SILTY CLAY LOAM, HEAVY VARIANT.	<b>PdB</b>	PALISADE VERY FINE SANDY LOAM, 1 TO 3 PERCENT SLOPES.
<b>KIB</b>	KILLPACK CLAY LOAM, 1 TO 3 PERCENT SLOPES.	<b>PnA</b>	PENOYER LOAM, EXTENDED SEASON, 0 TO 1 PERCENT SLOPES.
<b>KIC2</b>	KILLPACK CLAY LOAM, 3 TO 6 PERCENT SLOPES, ERODED.	<b>RIB</b>	RAVOLA LOAM, 1 TO 3 PERCENT SLOPES.
<b>KpB</b>	KILLPACK LOAM, 1 TO 3 PERCENT SLOPES.	<b>SIB</b>	SANGETE SANDY CLAY LOAM, 1 TO 3 PERCENT SLOPES.
<b>KpC2</b>	KILLPACK LOAM, 3 TO 6 PERCENT SLOPES, ERODED.		
<b>Lb</b>	LIBBINGS SILTY CLAY LOAM.		
<b>MIB</b>	MINCHEY LOAM, 1 TO 3 PERCENT SLOPES.		
	DESIGNATED PRIME FARMLAND		

FIGURE XIII-1. SOIL TYPES IN THE IBC AREA.

It is unlikely that raptors occur within the IBC area. One prairie dog community is located with the IBC area (see Chapter IX of the approved MRP). Given the lack of planned subsidence, it is not anticipated that impacts will occur to these or other wildlife resources from coal mining in the IBC area. Although several Federally-listed threatened or endangered animal species are known to occur in Emery County, a lack of appropriate habitat greatly reduces the potential for any of these species to occur within the IBC area (see Appendix XIII-2).

### **XIII.C.5 GEOLOGIC RESOURCE INFORMATION**

Information regarding geologic resources within the IBC and adjacent areas is provided in Chapter V of the approved MRP. The Bluegate Shale member of the Mancos Shale outcrops over the entire surface of the IBC area. This unit is a saline, blue-gray silty mudstone and siltstone with occasional, thin sandstone lenses. The Bluegate Shale abruptly overlies the Ferron Sandstone member of the Mancos Shale. The Ferron Sandstone consists of interbedded layers of sandstone, siltstone, shale, and coal, with the coal to be mined in the IBC area occurring in the upper portion of the Ferron Sandstone in a layer known as the IJ zone. The Tununk Shale member of the Mancos Shale underlies the Ferron Sandstone.

Based on data provided on Plate V-20 of the approved MRP, approximately 300 to 500 feet of overburden overlies the IJ zone within the IBC area. Roof and floor materials above and below the IJ zone within the IBC area are expected to be as indicated in Section V.A.4 of the approved MRP, consisting of interbedded sandstone and shale. Dark gray shale typically contacts the roof of the coal, with several feet of irregularly laminated, light gray, fine-grained quartz sandstone above the shale. The floor material is generally dark olive gray, coaly, silty shale interbedded with light gray, fine grained quartz sandstone.

According to Section V.A.4 of the approved MRP, the pH of the roof material ranges from about 5 to 9, with the pH of the floor materials tending to be slightly higher. The roof and floor materials tend to have low salinity (specific conductance less than 4.0 mmhos/cm), with moderate to high sodium adsorption ratios (1.8 to 28) and concentrations of heavy metals that are sufficiently low to not influence reclamation decisions.

The coal, overburden, and underburden in the IBC area are unlikely to have substantial acid-forming potential, as indicated by the pH of the rock and the slightly alkaline nature of water that has historically discharged from the Emery Mine (pH 7.1 to 8.5 – see Section V.A.5 of the approved MRP). Furthermore, as indicated in Section V.A.6 of the approved MRP, the sulfur content of the coal is generally low (typically 0.5 to 2.0 percent, with an average of about 0.7 percent), with variable proportions of the sulfur existing as pyrite. Concentrations of toxic constituents in the coal, overburden, and underburden are low (see Section V.A.4 of the approved MRP).

A comparison of Plates V-20 and VI-4 of the approved MRP indicates that the complete thickness of the Ferron Sandstone is probably saturated within the IBC area. Additional information regarding groundwater within the IBC and adjacent areas is provided below and in Chapter VI of the approved MRP.

### **XIII.C.6 HYDROLOGIC RESOURCE INFORMATION**

#### **XIII.C.6.1 Baseline Information**

Mining within the IBC area will not involve the construction of additional surface facilities. Furthermore, as indicated in Section XIII.A, coal will be mined under this application using room and pillar methods without pillar extraction (i.e., first mining only). Hence, no surface disturbance is planned.

Baseline hydrologic data have been collected from several surface and groundwater monitoring locations adjacent to the IBC area (see Plates VI-1 and VI-3 of the approved MRP). These data are discussed in Chapter VI of the approved MRP. Given the lack of surface disturbance planned for the IBC area and the close location of the IBC area relative to the existing permit area, the existing baseline data are considered adequate for the IBC area.

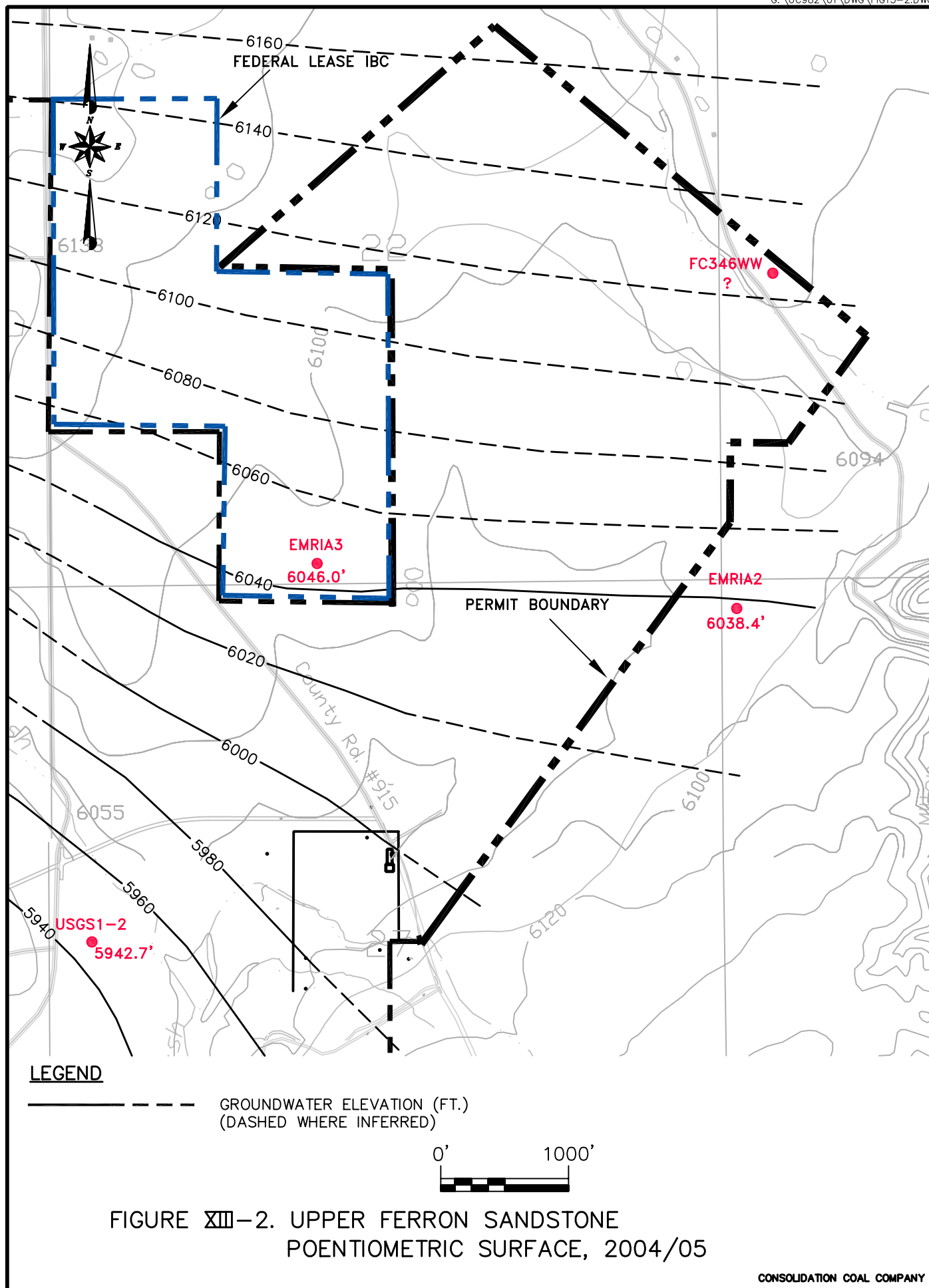
#### **XIII.C.6.2 Groundwater Information**

As indicated in Chapter VI of the approved MRP, the complete thickness of the Ferron Sandstone is probably saturated within the IBC area, normally under confined conditions. Although the formation dips to the northwest (see, for instance Plate V-20), groundwater flows generally to the south or southeast (see Plates VI-5 and VI-9 as well as Figure XIII-2) except where influenced by mining in the area (Plate V-4). The hydrostatic pressure required to force groundwater up dip in the mine area is generally believed to originate from recharge along the Joe's Valley-Paradise fault zone located at higher elevations north and west of the mine area.

Although the Ferron Sandstone is completely saturated within the existing mine area, historic inflows to the mine have been predominantly from the roof rather than the floor. This suggests that the upper and lower portions of the Ferron Sandstone are hydraulically separated. This hydraulic separation is also suggested by a comparison of Plates VI-4 and VI-5 of the approved MRP, which indicates that past impacts of mining on the potentiometric surface of the area have occurred primarily in the upper Ferron Sandstone, with no noticeable potentiometric-surface impacts in the lower Ferron Sandstone.

Groundwater discharges from the Ferron Sandstone by wells, by dewatering of the Emery Mine, by seepage into Quitcupah Creek and Christiansen Wash, and by leakage into the Bluegate and Tununk Shales. Within the immediate vicinity of the IBC area, the largest anthropogenic discharge of groundwater from the Ferron Sandstone is dewatering of the Emery Mine which, according to Chapter VI of the approved MRP, accounts for approximately 0.6 to 1.2 cubic feet per second of water being removed from the Ferron Sandstone.

Natural groundwater quality in the *upper* Ferron Sandstone is moderately saline, with total dissolved solids concentrations in monitoring well and mine roof inflow samples averaging approximately 1000 to 1300 mg/l (see Table VI-9 of the approved MRP). The total dissolved



solids concentration of groundwater in the *lower* Ferron Sandstone tends to be slightly less, averaging approximately 800 mg/l (see the previously noted table). This difference in salinity further suggests a hydraulic separation between the upper and lower Ferron Sandstone. Sodium and sulfate are the dominant ions in groundwater occurring in both the upper and lower Ferron Sandstone.

#### XIII.C.6.3 Surface Water Information

The IBC area lies within the drainage basin of Christiansen Wash, a perennial tributary to Quitcupah Creek. The only surface water courses within the IBC area are small ephemeral rills. No definitive stream channels exist within the IBC area.

Information regarding surface water resources in the vicinity of the IBC area is provided in Section VI.A.3 of the approved MRP. As indicated in that section, streamflow in Christiansen Wash generally increases in the downstream direction, primarily due to irrigation return flow and inflow from a tributary south of the IBC area that carries spring water to the wash. Peak flows in Christiansen Wash typically occur in mid to late spring as a result of snowmelt runoff and then again in mid to late summer due to thunderstorms. Irrigation return flows contribute to Christiansen Wash during the summer months.

Data presented in Chapter VI of the approved MRP indicate that concentrations of dissolved constituents generally increase in the downstream direction along Christiansen Wash. This is attributed to irrigation return flow seeping into the stream. The total dissolved solids concentration of Christiansen Wash ranges from about 1,000 to 5,000 mg/l and is typically indirectly related to discharge rate. Calcium, sodium, and sulfate are the dominant ions. Total suspended solids concentrations vary widely in Christiansen Wash (from less than 100 to more than 3,000 mg/l) and tend to be directly related to discharge rate.

#### XIII.C.6.4 Baseline Cumulative Impact Information

The Federal Lease IBC area lies within the cumulative impact area of the Emery Mine.

#### XIII.C.6.5 Modeling

No surface or groundwater modeling was performed for this IBC application.

#### XIII.C.6.6 Alternative Water Source Information

As indicated in Section VI.A.4 of the approved MRP, two private wells in the vicinity of the Emery Mine (the Bryant well and the Lewis well) have stopped flowing at the surface as a result of dewatering activities at the Emery Mine. Consol has furnished and installed pumps and associated appurtenances to allow continued use of this water. Consol has also committed to drill new wells if needed to replace these water supplies.

It is doubtful that mining within the IBC area will substantially change the magnitude of past impacts to the hydrology of the Emery Mine area (see Section XII.C.6.7 of this application).

However, the above commitment to provide alternative sources of water, if necessary, remains in effect for mining activities in the IBC area.

#### XIII.C.6.7 Probable Hydrologic Consequences Determination

The probable hydrologic consequences of mining in the IBC area will be the same as noted in Section VI.A.7 of the approved MRP, namely:

- Changes to the potentiometric surface of the Ferron Sandstone (particularly the upper portion) due to mine dewatering activities and
- Changes in the quality and quantity of surface water in the area due to the discharge of intercepted mine water.

The *maximum* quantity of groundwater to be encountered in the IBC area was estimated based on the inflow per unit area to the existing portion of the Emery Mine. Data presented in Section VI.A.7 of the approved MRP indicate that inflow to the Emery Mine in 1989 and 1990 averaged approximately 1.0 cubic foot per second (i.e., 450 gallons per minute). Mine workings at that time occupied an underground area of approximately 1,440 acres (see, for instance, Plate VI-4 and several other plates that utilize the same base map). Assuming mine workings in the IBC area occupy the entire underground area of approximately 160 acres (see Plate IV-2 of the approved MRP) and assuming an equivalent inflow per unit area, mining in the IBC area may increase inflow to the Emery Mine by a *maximum* of about 0.11 cubic foot per second (about 50 gallons per minute).

Notwithstanding the above estimate, the IBC area is located up dip from most of the remainder of the Emery Mine, indicating that hydraulic pressures are naturally less in the IBC area than in the area of current mine workings further west. Furthermore, dewatering operations in the remainder of the Emery Mine have likely already dewatered a portion of the IBC area (see Plate VI-8 of the approved MRP). These factors indicate that groundwater inflow to the IBC workings will be less per unit area than in the remainder of the Emery Mine. Hence, total inflow to the IBC workings should be substantially less than 0.11 cubic foot per second (50 gallons per minute).

According to Section VI.A.7 of the approved MRP, mining of the IJ zone will not degrade groundwater quality in the Emery Mine permit and adjacent areas. A similar lack of groundwater quality impacts is anticipated from mining in the IBC area.

It is estimated from information contained in Section VI.A.7 of the approved MRP that approximately 0.1 cubic foot per second of groundwater that normally *would* seep into the Quitchupah Creek is intercepted in the Emery Mine and prevented from naturally discharging to the creek. However, this reduction in surface-water flow is offset by discharging to the creek approximately 1.0 cubic foot per second of groundwater intercepted in the mine. Hence, the net impact of mining in the Emery Mine on the flow of Quitchupah Creek is a flow increase of approximately 0.9 cubic foot per second. Water intercepted in the IBC area may slightly increase this net effect.



Water in the Emery Mine comes into contact with rock dust, thereby increasing the total dissolved solids concentration of this water prior to being pumped to the surface into Quitchupah Creek. Similar impacts are anticipated from mining in the IBC area. According to Section VI.A.7 of the approved MRP, the salt load of Muddy Creek (into which Quitchupah Creek eventually discharges) is expected to increase 10 to 17 percent as a result of mining in the Emery Mine. The salt load of the Dirty Devil River (into which Muddy Creek discharges) has historically increased less than 1 percent due to mine-water discharges. Assuming the total dissolved solids concentration of water discharging from the IBC area is similar to that in the remainder of the Emery Mine, and assuming that mining in the IBC area results in an increase in the mine-water discharge to Quitchupah Creek of 5 percent, the total salt load of Muddy Creek will increase 1 to 2 percent due to mining in the IBC area. No water rights exist downstream of the mine discharge point on Quitchupah Creek or Ivie Creek (the receiving stream for Quitchupah Creek). Hence, no substantially increased impacts to water users are anticipated from salt loading due to mining in the IBC area.

No additional surface area will be disturbed under this application. Hence, additional sediment loads to local streams will not occur.

### **XIII.D OPERATION PLAN**

#### **XIII.D.1 MINING OPERATIONS AND FACILITIES**

Coal will be extracted under this application using room and pillar methods without pillar extraction (i.e., first mining only). It is anticipated that approximately 900,000 tons of coal will be mined from the IBC area. Mining will occur using a continuous miner. General criteria for pillar design are provided in Section V.B.1 of the approved MRP.

No new surface facilities will be constructed under this application. Facilities associated with the Emery Mine that will be used during mining of the IBC area are discussed in Chapter II of the approved MRP.

The anticipated sequence of mining in the IBC area is indicated on Plate IV-2. This map also shows existing and anticipated underground workings within the current permit area and, for completeness only, potential mine workings outside of both the current permit area and the Federal Lease IBC area. Coal will not be extracted from areas outside the current permit area or the Federal Lease IBC area until those areas are properly permitted.

Although no subsidence is planned under this application, Plate V-5 shows locations of proposed subsidence monitoring stations in the IBC and adjacent areas. These stations will be established as indicated in Figure V-8 of the approved MRP. These stations will be monitored as outlined in Section V.B.1 of the approved MRP.

### **XIII.D.2 EXISTING STRUCTURES**

No “existing structures”, as defined in R645-100-200, exist in the IBC area. Structures located in other portions of the permit area that will be used during mining of the IBC area are discussed in Chapter II of the approved MRP. These structures will not be modified under this application.

### **XIII.D.3 COAL RECOVERY**

Coal will be recovered in a manner that maximizes utilization and recovery of the resource while maintaining environmental integrity. This plan will be modified if future designs call for extraction of the pillars.

### **XIII.D.4 SUBSIDENCE CONTROL PLAN**

No subsidence is planned for the IBC area.

### **XIII.D.5 HYDROLOGIC INFORMATION**

Information regarding surface and groundwater resources and probable hydrologic impacts of mining in the Federal Lease IBC and adjacent areas is provided in Section XIII.C.6 of this application. A discussion of surface and groundwater monitoring programs associated with the Emery Mine is provided in Section VI.A.5 of the approved MRP. Information regarding the acid- and toxic-forming potential of the coal, overburden, and underburden is discussed in Section XIII.C.5 of this application.

No surface disturbances are planned in the IBC area. Hence, no new diversions, stream buffer zones, sediment control structures, or other treatment facilities will be installed as a result of mining in the Federal Lease IBC area.

### **XIII.E RECLAMATION PLAN**

No new surface disturbances will occur as a result of mining in the Federal Lease IBC area. Hence, no additional land reclamation will be required as a result of this action. Information regarding reclamation of the Emery Mine surface facilities is provided in Chapter III of the approved MRP. This information includes a discussion of surface and groundwater monitoring programs, structure removal, backfilling and grading operations, drainage control, topsoil redistribution, site revegetation, etc.

### **XIII.F CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT**

The Federal Lease IBC area lies within the existing cumulative hydrologic impact assessment (“CHIA”) area associated with the Emery Mine. The CHIA that was previously prepared in conjunction with permitting the Emery Mine should be sufficient for evaluating the hydrologic impacts of the Federal Lease IBC area.

### **XIII.G REFERENCES**

Consolidation Coal Company  
Emery Mine

Federal Lease Incidental Boundary Change  
September 12, 2006

Swenson, J.L., D.T. Erickson, K.M. Donaldson, and J.J. Siozaki. 1970. Soil Survey of Carbon-Emery Area, Utah. U.S. Soil Conservation Service (now the U.S. Natural Resources Conservation Service). Salt Lake City, Utah.

U.S. Natural Resources Conservation Service. 2006. Official Soil Series Descriptions. Available online at <http://soils.usda.gov/technical/classification/osd/index.html>. Accessed 28 Aug 2006.

Consolidation Coal Company  
Emery Mine

Federal Lease Incidental Boundary Change  
September 12, 2006

## **APPENDIX XIII-1**

Soil Descriptions

# CHIPETA SERIES

The Chipeta series consists of very shallow and shallow, well drained, slowly permeable soils that formed in residuum and colluvium from shale. Chipeta soils are on upland pediments and hills and have slopes of 0 to 35 percent. The average annual precipitation is about 7 inches and the mean annual temperature is about 50 degrees F.

**TAXONOMIC CLASS:** Clayey, mixed, active, calcareous, mesic, shallow Typic Torriorthents

**TYPICAL PEDON:** Chipeta silty clay loam -cultivated. (Colors are for air-dry soil unless otherwise noted.)

**Ap**--0 to 5 inches; light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak fine subangular blocky structure; hard, firm, sticky and plastic; few fine and medium roots; few fine discontinuous pores; violently effervescent; slightly alkaline (pH 7.7); clear smooth boundary. (1 to 5 inches thick)

**C**--5 to 13 inches; light brownish gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) moist; moderate medium and fine subangular blocky structure; hard, very firm, sticky and plastic; few fine and medium roots; few large continuous pores, few fine discontinuous pores; violently effervescent; slightly alkaline (pH 7.6); clear wavy boundary. (6 to 10 inches thick)

**Cy**--13 to 17 inches; light brownish gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) moist; weak, moderately thick platy structure parting to weak medium blocky; hard, very firm, sticky and plastic; few fine and medium roots; many fine crystals and mycelia-like veins of gypsum; 20 percent unweathered shale fragments; violently effervescent; slightly alkaline (pH 7.4); gradual irregular boundary. (3 to 5 inches thick)

**Cr**--17 inches; weathered marine shale.

**TYPE LOCATION:** Emery County, Utah; 1 mile south and 1-1/2 miles east of Castle Dale, 1,000 feet south and 20 feet east of the northwest corner, sec. 11, T. 19 S., R. 8 E.

## **RANGE IN CHARACTERISTICS:**

Soil moisture regime: Typic Aridic.

Soil temperature regime: Mesic.

Depth to shale: 5 to 20 inches.

Salinity: moderate to strong.

Particle-size control section: 35 to 50 percent clay.

Mean annual soil temperatures: 49 to 57 degrees F.

Reaction: slightly alkaline to strongly alkaline.

A horizon:

Hue: 10YR to 5Y

Value: 5 to 8 dry, 3 to 6 moist  
Chroma: 2 to 4  
Texture: loam or silty clay loam

C horizon:  
Hue: 10YR to 5Y  
Value: 4 to 6 dry, 3 to 5 moist  
Chroma: 1 to 4  
Textures: silty clay loam or silty clay  
Gypsum: 0.5 to 10 percent and gypsum crystal ranges from few to many.

**GEOGRAPHIC SETTING:** These soils are on gently sloping to steep upland pediments and hills. Slopes are complex and range from 0 to 35 percent. These soils formed in residuum from alkaline marine shales containing gypsum. The climate is semiarid. The mean annual temperature is 45 to 55 degrees F. The freeze-free period ranges from 90 to 160 days. Mean annual precipitation ranges from 5 to 11 inches.

**DRAINAGE AND PERMEABILITY:** Well drained; medium to very high runoff; slow permeability.

**USE AND VEGETATION:** A few of the smoother areas of deeper soil are irrigated and used for growing grain and hay crops. Potential vegetation is mat saltbush and galleta.

**DISTRIBUTION AND EXTENT:** Western Colorado, Wyoming, eastern Utah, and New Mexico. LRR D, MLRA 34. The series is extensive.

**REMARKS:**

All pH values given are of soil paste.  
Diagnostic horizons and features recognized in this pedon are:  
Ochric epipedon-the zone from the surface to 5 inches (Ap horizon)  
Shallow feature-weathered shale at 17 inches (Cr horizon)

**CHIPETA-PERSAYO ASSOCIATION, 1 TO 3 PERCENT SLOPES (CPB):** This mapping unit consists of about 60 percent Chipeta silty clay loam, 1 to 3 percent slopes, and of about 40 percent Persayo loam, 1 to 3 percent slopes. These soils are intermingled and occur in no consistently identifiable pattern. Consequently, they were not separated in mapping. As a rule, the Chipeta soil is on ridges and has stronger slopes than the Persayo soil.

Included in the mapping were some areas of very shallow unnamed soils. Also included were other soils that are 20 to 40 inches thick over shale and small areas, generally less than 1 acre in extent, of strongly saline-alkali soils.

The profile of Chipeta silty clay loam, 1 to 3 percent slopes, is the one described as typical for the series. In most places this soil is 10 to 20 inches thick over shale. It has good drainage and is

slowly permeable. Runoff is medium, and the susceptibility to erosion is moderate. Roots penetrate to the shale and then spread horizontally. This Chipeta soil retains about 3 inches of available water. The soil is hard to work and to irrigate. Leveling is not practical, because this soil is too shallow.

The Persayo soil in this mapping unit has a profile like the one described for the Persayo series. Erosion has mainly caused the formation of rills and shallow gullies.

The dominant use of the soils in this mapping unit is spring and fall range. Alfalfa, grain, and pasture plants are grown in the irrigated areas, but the soils are poorly suited to those crops. Hay and pasture effectively reduce soil losses most of the time. (Both soils are in capability unit VIe-23, irrigated. The Chipeta soil is in capability unit VIIe-D3, nonirrigated; Desert Shale range site. The Persayo soil is in capability unit VIIe-D4, nonirrigated; Desert Loamy Shale range site)

# FERRON SERIES

The Ferron series consists of very deep, poorly drained, moderately permeable soils that formed in alluvium on flood plains. Slopes are 0 to 3 percent. The average annual precipitation is about 8 inches and mean annual temperature is about 49 degrees F.

**TAXONOMIC CLASS:** Coarse-silty, mixed, active, calcareous, mesic Aeric Fluvaquents

**TYPICAL PEDON:** Ferron silt loam. (Colors are for air-dry soil unless otherwise noted.)

**0i**--1 inch to 0; undecomposed organic material, mainly grass roots; strongly calcareous, moderately alkaline (pH 8.3); abrupt smooth boundary. (0 to 3 inches thick)

**Agy**--0 to 3 inches; light brownish gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) moist, common fine prominent yellowish red (5YR 4/8) redoximorphic and common medium faint dark gray (4/0) redoximorphic depletions; weak thick platy structure parting to weak medium granular; slightly hard, friable, slightly sticky and slightly plastic; many fine and few medium roots; few medium and fine pores; moderately calcareous; moderately alkaline (pH 8.3); clear smooth boundary. (3 to 8 inches thick)

**Cgy**--3 to 15 inches; light brownish gray (2.5Y 6/2) loam, grayish brown (2.5Y 5/2) moist, many medium distinct olive brown (2.5Y 5/6) redoximorphic concentrations; weak moderately thick platy structure parting to weak medium granular; soft, friable, slightly plastic; many medium and fine roots; common fine pores; many gypsum mycelia; moderately calcareous; mildly alkaline (pH 7.8); gradual wavy boundary. (6 to 12 inches thick)

**Cg**--15 to 60 inches; light brownish gray (2.5Y 6/2) very fine sandy loam, brownish gray (2.5Y 5/2) moist, many medium and faint light olive brown (2.5Y 5/6) redoximorphic concentrations; massive; soft, friable; common medium and few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.7).

**TYPE LOCATION:** Emery County, Utah; 2 miles northwest of Huntington, 350 feet north and 20 feet west of the southeast corner of sec. 11, T. 17 S., R. 8 E.

**RANGE IN CHARACTERISTICS:** Mean annual soil temperatures range from 49 to 54 degrees F.

Ferron soils have mottles within 20 inches of the surface. The seasonal high water table ranges between the 6 and 30 inch depths. Calcium carbonate equivalent ranges from 10 to 25 percent. It ranges from slightly saline to strongly saline. Reaction ranges from mildly alkaline to strongly alkaline. The 10 to 40 inch contains less than 18 percent clay and less than 15 percent sand coarser than very fine sand, and it ranges in texture from very fine sandy loam to light silt loam, with the strata of fine sandy loams.



The A horizon has hues of 2.5Y through 5Y, values of 5 or 6 dry, 4 or 5 moist, and chromas of 1 or 2.

The C horizon has hues of 2.5Y through 5Y, values of 5 or 6 dry, and 4 or 5 moist, and chromas of 2. There is a subhorizon in the upper C horizon between 10 and 30 inches that has hue of 2.5Y, value 4 or 5 moist, and a chroma of 2.

**GEOGRAPHIC SETTING:** These soils are on flood plains and in the bottoms of narrow alluvial valleys. Slopes are 0 to 3 percent. Parent material is alluvium derived from marine shale and sandstone. The climate is semiarid. Mean annual temperatures is 47 to 52 degrees F. Mean annual precipitation ranges from 6 to 10 inches. The freeze-free period is from 100 to 140 days.

**DRAINAGE AND PERMEABILITY:** Poorly drained. Runoff slow; permeability moderate.

**USE AND VEGETATION:** Used for pasture. Potential vegetation is tufted hairgrass, redtop, native clover, and sedges.

**DISTRIBUTION AND EXTENT:** Mainly in eastern Utah. The series is inextensive. MLRA 34

**REMARKS:** Diagnostic horizons and features in this pedon include:

Ochric epipedon - the zone from 0 to 3 inches (Agy horizon).

Aquic feature - 2 chroma matrix and redoximorphic concentrations from 3 to 20 inches (Agy and upper Cgy horizons).

There is an irregular decrease in organic matter with depth.

All pH values given are of soil paste.

The classification was changed from Typic Fluvaquent to Aeris Fluvaquent in 9/94.

**FERRON SILTY CLAY LOAM, HEAVY VARIANT, 0 TO 3 PERCENT SLOPES (FE):**

This soil occurs in small, low areas that receive seep water from higher lying canals and irrigated areas. Its profile is the one described for the heavy variant of the Ferron series.

Grazing is the only use of this soil. Some areas can be grazed only in winter when the soil is frozen. (Capability unit Vw-2W, nonirrigated; Wet Meadow range site)

# KILLPACK SERIES

The Killpack series consists of moderately deep, well drained, slowly permeable soils that formed in alluvium and residuum from saline marine shale. Killpack soils are on sideslopes and toeslopes of rolling shale hills. Slopes are 1 to 25 percent. Average annual precipitation is about 7 inches and mean annual temperature is about 52 degrees F.

**TAXONOMIC CLASS:** Fine-silty, mixed, active, calcareous, mesic Typic Torriorthents

**TYPICAL PEDON:** Killpack clay loam, cropland. (Colors are for air-dry soil unless otherwise noted.)

**Ap--**0 to 9 inches; brownish gray (2.5Y 5/2) clay loam, dark grayish brown (2.5Y 4/2) moist; weak medium and fine granular structure; hard, firm, slightly sticky and slightly plastic; common fine roots; common fine pores; strongly calcareous; mildly alkaline (pH 7.8); clear smooth boundary. (6 to 9 inches thick)

**C--**9 to 23 inches; light brownish gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) moist; moderate coarse subangular blocky parting to weak fine subangular blocky structure; hard, firm, sticky and plastic; few fine roots; few fine pores; strongly calcareous; mildly alkaline (pH 7.7); gradual wavy boundary. (8 to 21 inches thick)

**Cy--**23 to 29 inches; light brownish gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) moist; massive; hard, very firm, sticky and plastic; few fine roots; strongly calcareous; mildly alkaline (pH 7.7); many gypsum crystals 5 to 15mm in diameter; gradual wavy boundary. (6 to 10 inches thick)

**Cr--**29 inches; light brownish gray weathered shale.

**TYPE LOCATION:** Emery County, Utah; 2 miles northwest of Elmo, northeast of the Elmo road and the Cleveland-Price road; 2,450 feet north and 300 feet east of the SW corner of sec. 30, T. 16 S., R. 10 E.

**RANGE IN CHARACTERISTICS:** Soil temperatures are more than 47 degrees F. Depth to shale bedrock ranges from 20 to 40 inches. There is a few to common gypsum crystals accumulated immediately above the shale. Clay minerals are mixed but dominantly illite and kaolinite. The particle-size control section ranges from silty clay loam to silt loam with 18 to 35 percent clay.

The A horizon has hue of 10YR through 5Y, dry value of 5 or 6, moist value of 4 or 5, and chroma of 2 through 4.

The C horizon has hue of 10YR through 5Y, value of 5 through 7 dry, 3 through 7 moist, and chroma of 2 through 4.

The Cy horizon has the same color as the C horizon and contains 5 to 15 percent shale channers.

**GEOGRAPHIC SETTING:** These soils are on the gentle sideslopes of rolling shale hills. Slope gradients range from 1 to 25 percent. Killpack soils formed in alluvium and residuum from saline marine shale. The climate is semiarid with mean annual temperature of 47 to 55 degrees F. Mean annual precipitation ranges from 5 to 11 inches.

**DRAINAGE AND PERMEABILITY:** Well drained; medium to rapid runoff; slow permeability.

**USE AND VEGETATION:** Cultivated areas are used for grain, alfalfa hay, and irrigated pasture. The remaining areas are used for rangeland. Potential vegetation is shadscale, greasewood, galleta grass, and gardner saltbush.

**DISTRIBUTION AND EXTENT:** Eastern Utah and western Colorado. The series is moderately extensive.

**REMARKS:** The pH values were determined of soil paste.

**KILLPACK CLAY LOAM, 1 TO 3 PERCENT SLOPES (K1B):** The profile of this soil is the one described as typical of the series. Included in mapping were small areas in which the soil is thicker than 40 inches and places where it is less than 20 inches thick over shale. Also included were small areas of strongly and very strongly saline soils, and a small area south and west of Moore in which the soil is brown above a depth of 24 inches.

Drainage is good, and permeability is slow. Runoff is medium, and the susceptibility to erosion is moderate. Roots penetrate to the shale, and then they spread horizontally. About 4 to 5 inches of water is retained by this soil, but only about 2 to 2.5 inches, the amount depending on the depth to shale, is readily available to plants. This soil is hard to work, and generally it is hard to irrigate. The seedbed is more easily prepared if this soil is plowed in fall when it is barely moist, and is allowed to remain rough over winter, than when it is plowed in spring.

This soil is used for spring and fall range, for irrigated pasture, and for irrigated alfalfa and small grains. The growing season is only long enough for two full crops of alfalfa and for a part of a third to mature. (Capability units IVE-25, irrigated, and VIIs-D, nonirrigated; Desert Loam Bottom range site)

**KILLPACK CLAY LOAM, 3 TO 6 PERCENT SLOPES, ERODED (KIC2):** This soil is steeper and more eroded than the one for which a profile is described as typical for the series. Included in mapping were small areas of clayey soils and some areas in which the soils are deeper than 40 inches over shale. Also included were places, generally near the shaly colluvial slopes, where gravel is on the surface and in the surface layer.

This Killpack soil is fairly close to nearly bare shale hills that contribute considerable runoff. Runoff is rapid, and the susceptibility to erosion is high. Gullies 3 to 6 feet deep and 100 to 300

feet apart are common. In some places most of the surface layer has been lost through sheet erosion.

This soil is used mainly for range. It is also used for alfalfa, small grains, and pasture crops grown under irrigation, but it is not well suited to those uses. (Capability units VIe-23, irrigated, and VIIe-D, nonirrigated; Desert Loam Bottom Range site)

**KILLPACK LOAM, 1 TO 3 PERCENT SLOPES (KpB):** The profile of this soil is similar to the one described as typical of the series, except that the surface layer is heavy loam, and the subsoil below a depth of 15 to 24 inches is light silty clay loam to light silty clay. In addition, the gypsum horizon is less prominent.

Included in mapping were small areas in which the surface layer is clay loam.

This Killpack soil is easy to work, and it absorbs water readily. The area that is cultivated and irrigated is limited in extent and is used for alfalfa, small grains, corn, and pasture. (Capability units IVE-25, irrigated, and VIIe-D, nonirrigated; Desert Loam Bottom range site)

**KILLPACK LOAM, 3 TO 6 PERCENT SLOPES, ERODED (KpC2):** The profile of this soil is similar to the one described as typical of the series, except the surface layer is heavy loam and the subsoil below a depth of 15 to 24 inches is silty clay loam or light silty clay.

Included in mapping were areas of deep loam and silty clay loam.

This Killpack soil is on the side slopes of shale hills. Runoff is rapid, sheet erosion is active, and the susceptibility to erosion is high. Near bare shale hills, this soil contains gullies 3 to 6 feet deep and 100 to 300 feet apart. This soil absorbs water readily. It is easy to till and cultivate but is difficult to irrigate.

Most areas of this soil are in native range. Areas that are cultivated and irrigated are limited in extent and are used mainly for alfalfa and pasture. Controlling erosion is an important management requirement. (Capability units VIe-23, irrigated, and VIIe-D, nonirrigated; Desert Loam Bottom range site)

# LIBBINGS SERIES

The Libbings series consists of moderately deep, poorly drained, slowly permeable soils that formed in alluvium and residuum from shale. Libbings soils occur on low rolling hills and have slopes of 0 to 3 percent. The average annual precipitation is about 7 inches and the mean annual temperature is about 47 degrees F.

**TAXONOMIC CLASS:** Fine, mixed, active, mesic Gypsic Aquisalids

**TYPICAL PEDON:** Libbings silty clay loam. (Colors are for air-dry soil unless otherwise noted.)

**A1z**--0-1/2 inch; grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; moderate thick platy parting to moderate fine granular structure; hard, friable, sticky and plastic; many very fine vesicular pores; strongly calcareous; very strongly saline; thin salt crust on surface; strongly alkaline (pH 8.5); abrupt smooth boundary; (1/2 to 1 inch thick)

**A2z**--1/2 to 2 inches; grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; moderate fine granular structure; soft, firm, sticky and plastic; few very fine roots; many very fine vesicular pores; strongly calcareous; very strongly saline; very fine salt grains; strongly alkaline (pH 8.9); abrupt smooth boundary. (1 to 3 inches thick)

**Cz**--2 to 9 inches; light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; weak fine granular structure; very hard, very firm, sticky and very plastic; few fine and very fine roots; few fine and very fine discontinuous pores; strongly calcareous; very strongly saline; effloresced salt on some peds and in pores; strongly alkaline (pH 8.6); clear smooth boundary. (6 to 10 inches thick)

**Czy1**--9 to 25 inches; gray (2.5Y 6/1) silty clay, dark gray (2.5Y 4/1) moist; massive; very hard, very firm, sticky and very plastic; few medium and fine roots; few very fine discontinuous pores; strongly calcareous; very strongly saline; many salt and gypsum nodules; strongly alkaline (pH 8.6); gradual smooth boundary. (5 to 16 inches thick)

**Czy2**--25 to 34 inches; gray (2.5Y 6/1) silty clay, dark gray (2.5Y 4/1) moist; massive; very hard, very firm, sticky and plastic; few very fine roots; few very fine discontinuous pores; strongly calcareous; numerous soft gypsum nodules 5 to 15 mm in diameter; 5 to 10 percent shale fragments; strongly saline; strongly alkaline (pH 8.7); clear smooth boundary. (7 to 10 inches thick)

**Cr**--34 inches; soft platy shale. Roots and water concentrated between shale plates.

**TYPE LOCATION:** Emery County, Utah; 330 feet south and 160 feet east of the northwest corner of sec. 8, T. 17 S., R. 10 E.; about 2 miles south of Elmo, 1/4 mile west of Elmo-Cleveland Road.

**RANGE IN CHARACTERISTICS:** Depth to bedrock ranges from 20 to 40 inches. Depth to high water tables ranges from 10 to 30 inches. Salt content above 20 inches ranges from 2 to 5 percent. Exchangeable sodium is highest near the surface, 50 to 65 percent, and decreases with depth below 20 inches. Reaction is strongly alkaline to very strongly alkaline. The particle-size control section (10 to 40 inch depth) is dominantly silty clay, but ranges from heavy silty clay loam to clay more than 35 percent clay. Mean annual soil temperatures ranges from 49 to 53 degrees F.

The A horizon has hue of 10YR through 5Y with dry values of 5 or 6, moist values of 4 or 5, and chroma of 2.

The C horizon has hue of 1Y through 5Y, with dry values of 5 or 6, moist values of 4 or 5, and chromas of 1 or 2. Gypsum accumulation ranges from few to many, but there is typically 2 to 7 percent more gypsum in this horizon than in the underlying shale.

**GEOGRAPHICAL SETTING:** Libbings soils are on the footslopes of low rolling hills. Elevation is 5,400 to 5,500 feet. Slopes range from 0 to 3 percent. They are developed in residuum and alluvium from saline marine shale in areas where irrigation water or seepage from canals has caused salts to accumulate. The climate is semiarid, with mean annual temperature of 47 to 49 degrees. Mean annual precipitation ranges from 6 to 11 inches. Freeze-free period ranges from 110 to 140 days. **GEOGRAPHICALLY ASSOCIATED SOILS:** These are the Killpack, Chipeta, Persayo, Billings, and the competing Cache and Saltair soils. Killpack soils lack very strong salt horizons above 20 inches. Chipeta and Persayo are less than 20 inches deep over shale and lack very strong salt horizons. Billings soils are very deep and lack very strong salt horizons.

**DRAINAGE AND PERMEABILITY:** Poorly drained; runoff is medium; slow permeability.

**USE AND VEGETATION:** Native range is the only use of this soil. The potential vegetation is alkali sacaton, alkali bluegrass, saltgrass, pickleweed and greasewood.

**DISTRIBUTION AND EXTENT:** Eastern Utah. Libbings soils are extensive.

**REMARKS:** All pH values were determined of soil paste. The name is coined.

**LIBBINGS SILTY CLAY LOAM, 0 TO 3 PERCENT SLOPES (Lb):** The profile of this soil is the one described as typical of the series. The surface layer is only ¼ to ½ inch thick. It has a platy structure but typically breaks to granules containing numerous crystals of salt. The layer over the shale contains numerous crystals of gypsum or salt, but in some places these crystals are not present.

Included in mapping were minor areas in which shale is at a depth of more than 40 inches, and some areas in which the shale is at a depth of less than 20 inches. Also included were some areas of saline soils that contain less than 2 percent salt.

Drainage is poor, and permeability is slow above the shale. Runoff is medium, and this soil is moderately susceptible to erosion. The water table is 10 to 30 inches below the surface, and is highest early in summer. Mottles occur in some places. Water spread horizontally to top of the shale and penetrates to a depth of only a few inches. In some places, water moves freely between the plates of shale. Roots penetrate to the shale, and then they spread horizontally.

This soil is used for grazing. (Capability unit VIIw-28, nonirrigated; Salt Meadow range site)

# MINCHEY SERIES

The Minchey series consists of very deep, well drained, moderately permeable soils that formed in material weathered from sandstone and quartzite. Minchey soils are on mesas, benches, and old alluvial fans and have slopes of 0 to 10 percent. The average annual precipitation is about 8 inches, and the mean annual temperature is about 48 degrees F.

**TAXONOMIC CLASS:** Fine-loamy, mixed, active, mesic Typic Haplocalcids

**TYPICAL PEDON:** Minchey loam--rangeland. (Colors are for air-dry soil unless otherwise noted.)

**A1**--0 to 3 inches; pale brown (10YR 6/3) loam, brown (10YR 5/3) moist; weak thin platy structure parting to weak fine granular; soft, friable, slightly sticky and slightly plastic; few fine and medium roots; common medium vesicular pores; moderately calcareous; moderately alkaline (pH 8.2); clear smooth boundary. (2 to 6 inches thick)

**A2**--3 to 12 inches; brown (10YR 5/3) clay loam, dark brown (10YR 4/3) moist; moderate medium subangular blocky structure; hard, firm, slightly sticky and plastic; few medium and fine roots; many medium pores; moderately calcareous; moderately alkaline (pH 8.0); gradual wavy boundary. (6 to 10 inches thick)

**Bk1**--12 to 20 inches; pale brown (10YR 6/3) clay loam, brown (10YR 4/3) moist; moderate medium subangular blocky structure; hard, very firm, sticky and plastic; few fine and medium roots; few fine pores; strongly calcareous; carbonates are fine nodules and disseminated; moderately alkaline (pH 8.3); gradual wavy boundary. (8 to 12 inches thick)

**Bk2**--20 to 32 inches; very pale brown (10YR 8/3) sandy clay loam, very pale brown (10YR 7/3) moist; massive; hard, firm, slightly sticky and slightly plastic; few fine and medium roots; few fine pores; very strongly calcareous; carbonates are disseminated and in fine nodules; moderately alkaline (pH 8.2); diffuse wavy boundary. (10 to 15 inches thick)

**C1**--32 to 48 inches; pale brown (10YR 6/3) gravelly sandy loam, brown (10YR 5/3) moist; massive; slightly hard, very friable, slightly plastic; few fine roots; few fine pores; strongly calcareous; moderately alkaline (pH 7.9); gradual wavy boundary. (10 to 20 inches thick)

**C2**--48 to 64 inches; light yellowish brown (10YR 6/4) very gravelly sandy loam, yellowish brown (10YR 5/4) moist; single grained; loose, very friable, slightly plastic; few fine roots; strongly calcareous; moderately alkaline (pH 8.4).

**TYPE LOCATION:** Emery County, Utah; 4 miles north and 1 mile east of Elmo; 1,980 feet south and 140 feet west of the northeast corner of sec. 9, T. 16 S., R. 10 E.



**RANGE IN CHARACTERISTICS:** Average annual soil temperature is 47 to 53 degrees F. The soil moisture regime is Typic Aridic.

The depth to the calcic horizon ranges from 10 to 30 inches. The calcium carbonate equivalent ranges from 15 to 40 percent. The particle-size control section is clay loam, sandy clay loam, gravelly sandy loam, or gravelly sandy clay loam. It averages 18 to 35 percent clay and is more than 15 percent coarser than very fine sand. Gravel and cobbles range from 15 to 35 percent and occur in the lower one third of the particle-size control section. Below 40 inches, textures range from very gravelly sandy loam to extremely gravelly loamy sand, with 40 to 80 percent rock fragments. Reaction is moderately or strongly alkaline.

The A horizon has hue of 7.5YR or 10YR and value of 5 through 7 dry, 4 or 5 moist, and chroma of 2 or 4.

The Bk and C horizon has hue of 7.5YR or 10YR, value of 5 through 8 dry, 4 through 7 moist, and chroma of 3 or 4.

**GEOGRAPHIC SETTING:** These soils are on mesas or benches and old alluvial fans. Slope gradients are from 0 to 10 percent. Parent material is glacial outwash derived dominantly from sandstone and quartzite. Elevation is 5,400 to 6,000 feet. The climate is semiarid, with mean annual temperatures of 47 to 51 degrees F. Mean annual precipitation ranges from 5 to 9 inches. The freeze-free period is 110 to 130 days.

**DRAINAGE AND PERMEABILITY:** Well drained; medium runoff; moderate permeability.

**USE AND VEGETATION:** Cultivated areas are used for corn for silage, alfalfa, grain and improved irrigated pasture. Potential vegetation is galleta grass, blue grama, shadscale, needleandthread, Indian ricegrass, and winterfat.

**DISTRIBUTION AND EXTENT:** Plateau areas in Utah and Colorado. MLRA 34 and 35. The series is of moderate extent.

**REMARKS:** These soils have been correlated to desert range sites in Utah.

Diagnostic horizons and features in this pedon include:

Ochric epipedon - from 0 to 12 inches (A1 and A2 horizons).

Calcic horizon - from 12 to 32 inches (Bk1 and Bk2 horizons).

Classification change from Typic Calciorthids to Typic Haplocalcids on 11/94.

**MINCHEY LOAM, 1 TO 3 PERCENT SLOPES (MIB):** A profile of this soil is the one described as typical of the series. This soil normally is nonsaline.

Included in mapping were small areas of gravelly soils and of soils similar to this Minchey soil, except that the subsoil is loam or very fine sandy loam.

Drainage is good, and permeability is moderate. Runoff is medium, and the susceptibility to erosion is moderate. Roots generally penetrate deeply, but in places they are restricted by gravel and cobblestones at depths below 20 inches. The soil retains between 8 and 9 inches of water, but only 4.5 to 5.5 inches of water is readily available to plants. The frost-free season is 110 to 130 days in 3 out of 4 years.

This soil is used for spring and fall range. In addition, some areas are irrigated and are used for alfalfa, small grains, corn, and pasture. (Capability units IIe-24, irrigated, and VIIc-S, nonirrigated; Semi-Desert Loam Bench range site)

# PALISADE SERIES

The Palisade series consists of very deep, well drained soils that formed in lake sediments derived from limestone and sandstone. The Palisade soils are on lake terraces. Slope ranges from 1 to 10 percent. The mean annual temperature is 48 degrees F., and the mean annual precipitation is about 10 inches.

**TAXONOMIC CLASS:** Coarse-loamy, mixed, superactive, mesic Xeric Haplocalcids

**TYPICAL PEDON:** Palisade loam. (Colors are for dry soil unless otherwise noted).

**A**--0 to 6 inches; pale brown (10YR 6/3) silt loam, dark grayish brown (10YR 4/2) moist; weak, thin, platy structure; slightly hard, friable, slightly sticky, slightly plastic; common very fine roots; many fine and medium pores; moderately calcareous, lime is disseminated; moderately alkaline (pH 8.4); clear smooth boundary. (3 to 7 inches thick.)

**Bw**--6 to 12 inches; very pale brown (10YR 7/3) silt loam, brown (10YR 5/3) moist; weak, medium subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; common very fine roots; common very fine vesicular pores; moderately calcareous, lime is disseminated; strongly alkaline (pH 8.5); clear smooth boundary. (6 to 9 inches thick.)

**Bk1**--12 to 19 inches; very pale brown (10YR 7/3) silt loam, brown (10YR 5/3) moist; weak, medium and coarse, subangular blocky structure; hard, friable, slightly sticky, slightly plastic; few very fine roots; many very fine vesicular pores; strongly calcareous, lime is disseminated; strongly alkaline (pH 8.7); gradual wavy boundary. (5 to 8 inches thick.)

**Bk2**--19 to 30 inches; light gray (10YR 7/2) loam, brown (10YR 5/3) moist; weak, medium and coarse, subangular blocky structure; very hard, friable, nonsticky, nonplastic; few very fine roots; many very fine vesicular pores; strongly calcareous, lime is disseminated; very strongly alkaline (pH 9.4); gradual smooth boundary. (10 to 16 inches thick.)

**C1**--30 to 43 inches; pale brown (10YR 6/3) very fine sandy loam, brown (10YR 5/3) moist; massive; soft, friable, nonsticky, nonplastic; strongly calcareous, lime is disseminated; very strongly alkaline (pH 9.1); gradual wavy boundary.

**C2**--43 to 60 inches; pale brown (10YR 6/3) very fine sandy loam, dark brown (10YR 4/3) moist; massive; soft, friable, nonsticky, nonplastic; strongly calcareous, lime is disseminated; very strongly alkaline (pH 9.2).

**TYPE LOCATION:** Box Elder County, Utah; located about 400 feet north and 700 feet east of the southwest corner of sec. 11, T.9N., R.7W.; about 7 miles southwest of Golden Spike Monument.

**RANGE IN CHARACTERISTICS:** Soil temperatures are 48 to 54 degrees F.

The control section contains 8 to 18 percent clay and more than 15 percent coarser than very fine sand. Textures include very fine sandy loam, silt loam, and loam. In some places, the lower one-third of the control section contains gravel fragments and cobbles not exceeding 50 percent by volume.

The A horizon has hue of 10YR, values of 5 or 6 dry, and 4 or 5 moist, and chromas of 2 to 5.

The B and C horizons have hues of 7.5YR or 10YR, values of 5 to 7 dry, and 4 to 6 moist, and chromas of 2 to 4. Calcium carbonate content of the calcic horizons ranges from 20 to 40 percent.

**GEOGRAPHIC SETTING:** These soils are on lake terraces. Slope ranges from 1 to 10 percent. Parent material is lake sediments derived from limestone and sandstone. Mean annual air temperature is 46 to 52 degrees F. and the freeze free period ranges from 90 to 130 days. The mean annual precipitation ranges from 8 to 12 inches.

**DRAINAGE AND PERMEABILITY:** Well drained. Runoff is medium; permeability is moderate.

**USE AND VEGETATION:** Irrigated areas are used for growing alfalfa, small grains, and corn for silage. Present vegetation on unirrigated areas is dominantly shadscale and rabbitbrush. Potential vegetation under excellent management would be Indian ricegrass, needle-and-thread, squirreltail, and bud sage.

**DISTRIBUTION AND EXTENT:** Southern and eastern Utah, and possibly Colorado. The series is extensive.

**REMARKS:** Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - from the surface to 6 inches (A horizon).

Calcic horizon - from 12 to 30 inches (Bk1 and Bk2 horizons).

The classification is based on the "Keys to Soil Taxonomy, Eighth Edition, 1998". This Palisade series was last reviewed in the field in 1965. The type location was moved to Box Elder county with the 1998 update of the series.

**PALISADE VERY FINE SANDY LOAM, 1 TO 3 PERCENT SLOPES (PdB):** The profile of this soil is the one described as typical of the series. Where this soil has been cultivated, the surface layer is mixed with material from the subsoil and can no longer be recognized. Gravel and cobblestones are between depths of 2 and 5 feet in places.

Included in the mapping were areas of Minchey loam, and places where gravel and cobblestones are at a depth of less than 20 inches. Also included was a small acreage near the Carbon County

Airport of a soil that contains a lime-cemented hardpan. Another inclusion, on the Porphyry Bench west of Price, consists of a small acreage of soils in which the surface layer and the subsoil are not calcareous.

Drainage is good, and permeability is moderate. Root penetration is deep. About 9 inches of water is retained by this soil, but only 4.5 to 5.5 inches is readily available to plants. Runoff is medium, and the susceptibility to erosion is moderate. This soil is easy to work and to irrigate. Leveling is needed in many areas, however, to help obtain the uniform distribution of irrigation water. The frost-free season is 110 to 130 days in 3 out of 4 years.

This soil is used for spring and fall range, and for irrigated alfalfa, small grains, corn, and pasture. Because of the short growing season, alfalfa produces only two full crops and part of a third. Corn does not mature for grain and is used for ensilage. Alfalfa needs a large amount of phosphorus. (Capability units IIe-24, irrigated and VIIc-S, nonirrigated; Semi-Desert Loam Bench range site)

# PENoyer SERIES

The Penoyer series consists of very deep, well drained soils that formed in silty alluvium from limestone, volcanic rocks and lacustrine sediments. Penoyer soils are on inset fans, fan skirts, alluvial flats, flood plains, lake plains and alluvial fans. Slopes are 0 to 2 percent. The mean annual precipitation is about 7 inches and the mean annual temperature is about 54 degrees F.

**TAXONOMIC CLASS:** Coarse-silty, mixed, superactive, calcareous, mesic Typic Torriorthents

**TYPICAL PEDON:** Penoyer silt loam - rangeland. (Colors are for dry soil unless otherwise noted.)

**A**--0 to 4 inches; pale brown (10YR 6/3) silt loam, brown (10YR 5/3) moist; moderate thick platy structure; hard, friable, slightly sticky and slightly plastic; few fine and medium roots; strongly effervescent; strongly alkaline (pH 8.8); clear smooth boundary. (3 to 10 inches thick)

**C1**--4 to 17 inches; pale brown (10YR 6/3) silt loam, brown (10YR 5/3) moist; massive; slightly hard, friable, slightly sticky and slightly plastic; few fine and medium roots; common fine and medium vesicular pores, few fine tubular pores; strongly effervescent; strongly alkaline (pH 8.8); gradual smooth boundary. (4 to 20 inches thick)

**C2**--17 to 41 inches; pale brown (10YR 6/3) silt loam, brown (10YR 5/3) moist; massive; slightly hard, friable, slightly sticky, and slightly plastic; few fine and medium roots; common fine and medium vesicular pores; strongly effervescent; strongly alkaline (pH 8.8); clear smooth boundary. (5 to 40 inches thick)

**C3**--41 to 60 inches; pale brown (10YR 6/3) silt loam, brown (10YR 5/3) moist; weak thick platy structure that approaches massive in places; slightly hard, friable, slightly sticky and slightly plastic; few fine roots; few fine and very fine tubular pores; strongly effervescent; strongly alkaline (pH 8.8).

**TYPE LOCATION:** Lincoln County, Nevada; about 20 miles west of Caliente; 3.1 miles west of junction of Delamar road and U.S. Highway 93, and 0.2 mile north of U.S. Highway 93; about 700 feet south and 200 feet east of the northwest corner of section 8, T. 4 S., R. 64 E.; 37 degrees, 37 minutes, 14 seconds north latitude, 114 degrees, 50 minutes, 28 seconds west longitude.

## **RANGE IN CHARACTERISTICS:**

Soil moisture - Usually dry, moist in some part for short periods during winter and early spring months for 10 to 20 days cumulative between July and October due to convection storms.

Soil temperature - 53 to 59 degrees F. Control section - Clay content: Averages 10 to 18 percent.

A horizon - Hue: 7.5YR or 10YR. Value: 6 or 7 dry, 3 through 5 moist. Chroma: 2 through 4.

C horizon - Hue: 7.5YR or 10YR. Value: 6 or 7 dry, 3 through 5 moist. Chroma: 2 through 4.

Structure: Subangular blocky platy or massive. Consistence: Soft to hard, very friable or friable, slightly sticky to sticky and slightly plastic to plastic. Texture: Silt loam, but strata of very fine sandy loam, loam or silty clay loam are in some pedons. Effervescence: Strongly effervescent or violently effervescent. Reaction: Moderately alkaline to very strongly alkaline.

**GEOGRAPHIC SETTING:** Penoyer soils are on inset fans, fan skirts, alluvial flats, flood plains, lake plains, and alluvial fans. Slopes are 0 to 2 percent but are generally less than 1 percent. Elevations are 3,500 to 7,000 feet. They are crossed by a few shallow drainage channels. In places, wind deposited sandy hummocks, 2 to 4 inches high, are around the base of shrubs. Penoyer soils formed in silty alluvium derived from limestone, andesite, volcanic ash, basalt, tuff, sandstone and lacustrine sediments. The annual precipitation is 6 to 9 inches, the mean annual temperature is 51 to 56 degree F., and the frost-free season is 130 to 170 days.

**DRAINAGE AND PERMEABILITY:** Well drained; very slow runoff; moderate permeability.

**USE AND VEGETATION:** Most areas are used for rangeland. A few are irrigated and are used for growing alfalfa, small grain, potatoes and sugar beets. Dominant native plants are winterfat and some Indian ricegrass and galleta. Saltbush and greasewood are on saline or saline-alkali areas. Most of the surface area is bare.

**DISTRIBUTION AND EXTENT:** Central Nevada and southwestern Utah. The soil is of moderate extent. MLRA 29.

**REMARKS:** Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - The zone from the surface to 7 inches.

Particle-size control section - The zone from 10 to 40 inches.

Torriorthent features - Calcareous in all parts from 10 to 20 inches.

**PENOYER LOAM, EXTENDED SEASON, 0 TO 1 PERCENT SLOPES (PnA):** This soil is similar to the one for which a profile is described as typical of the series, except that it is nearly level and is near Green River, where the growing season is 140 to 160 days.

Included in mapping were soils that have slopes of 1 to 2 percent and some soils that have slopes of 3 to 6 percent. Included also were minor areas of soils that have a silty clay loam surface layer and a sandy loam subsoil.

Land leveling has been done in many fields, but it is still needed in some areas to improve the distribution of irrigation water. Runoff is slow, and the susceptibility to erosion is slight.

This soil is used for irrigated pasture, alfalfa, small grains, corn, melons, and sugar beets. Alfalfa produces three full cuttings a year, and corn matures for grain. (Capability unit I-1, irrigated; not rated for other uses)



# PERSAYO SERIES

The Persayo series consists of shallow, well drained soils on hills, terraces, and ridges. These soils formed in thin sediments weathered from underlying soft sedimentary bedrock. Slopes are 1 to 45 percent. The mean annual precipitation is about 9 inches and the mean annual temperature is about 51 degrees F.

**TAXONOMIC CLASS:** Loamy, mixed, active, calcareous, mesic, shallow Typic Torriorthents

**TYPICAL PEDON:** Persayo silty clay loam - grassland. (Colors are for dry soil unless otherwise noted.)

**A--**0 to 4 inches; light yellowish brown (2.5Y 6/3) silty clay loam, light olive brown (2.5Y 5/3) moist; moderate fine granular structure, weak platy in the upper 1/2 inch; soft, very friable; calcareous; moderately alkaline (pH 8.2); gradual smooth boundary. (3 to 7 inches thick)

**C--**4 to 14 inches; light yellowish brown (2.5Y 6/4) silty clay loam, light olive brown (2.5Y 5/4) moist; weak medium subangular blocky structure parting to moderate fine granules; hard, very friable; few small calcium sulfate crystals; calcareous; moderately alkaline (pH 8.2) gradual smooth boundary. (7 to 14 inches thick)

**Cr--**14 inches; calcareous; gray and yellow shale and siltstone.

**TYPE LOCATION:** Montrose County, Colorado; 0.1 mile north of the southeast corner of Sec. 22, T. 51 N., R. 10 W.

## **RANGE IN CHARACTERISTICS:**

These soils are dry in all parts of the moisture control section for more than three-fourths of the time that the soil temperature is above 41 degrees F. Moisture regime is Typic Aridic. Mean annual soil temperature: 47 to 58 degrees F. Mean summer soil temperature: 60 to 75 degrees F. Depth to paralithic contact: 4 to 20 inches. Organic carbon: approximately .4 percent. The sand/clay ratio: less than 1 to about 3. Exchangeable sodium: typically less than 3 percent, but tends to increase as depth increases and differs among pedons. Calcium carbonate equivalent: 5 to 14 percent. Calcium sulfate: less than 1 to about 10 percent.

Particle-size control section (weighted average): Texture: silt loam, loam, clay loam, or silty clay loam

Clay content: 18 to 35 percent

Silt content: 30 to 65 percent

Sand content: 5 to 45 percent

Coarse fragments: usually less than 5 percent and range from 0 to 15 percent.

A horizon

Hue: 10YR to 5Y

Value: 5 to 7 dry, 4 to 6 moist

Chroma: 2 through 4

Reaction: slightly to strongly alkaline

Consistence: soft to slightly hard.

C horizon

Hue: 10YR through 5Y

Value: 5 or 6 dry, 4 or 5 moist

Chroma: 2 to 4

Reaction: slightly alkaline to strongly alkaline

It contains some visible calcium carbonate and gypsum which are not concentrated into a definite horizon of secondary accumulation and are considered to be characteristics of the parent sediments rather than pedogenic.

**GEOGRAPHIC SETTING:** These soils are on upland hills, terraces, and ridges. Slopes range from 1 to 45 percent. The soil formed in thin sediments weathered from underlying soft sedimentary bedrock. Elevation ranges from 5,000 to 6,800 feet. At the type location mean annual precipitation is 7 to 11 inches with peak periods of precipitation occurring during the late summer. Mean annual temperature ranges from 47 to 53 degrees F., and mean summer temperature is about 66 to 70 degrees F. Frost-free period ranges from 95 to 150 days. In Utah this soil has a mean annual precipitation of 6 to 8 inches, mean annual temperature of 48 to 50 degrees, and a frost-free season of 115 to 140 days at an elevation of 5,300 to 6,200 feet.

**DRAINAGE AND PERMEABILITY:** Well drained; medium to rapid runoff; moderate or moderately slow permeability.

**USE AND VEGETATION:** These soils are used almost exclusively for native pastureland. Native vegetation is salt sage, greasewood, shadscale, and scattered grasses.

**DISTRIBUTION AND EXTENT:** Western Colorado and Wyoming, northwestern New Mexico, and eastern Utah. The series is of large extent. MLRA 35.

**REMARKS:** Diagnostic horizons and features recognized in this pedon are:

Paralithic contact - at about 14 inches.

**PERSAYO-CHIPETA ASSOCIATION, 1 TO 20 PERCENT SLOPES, ERODED (PCE2):**

About 60 percent of this mapping unit is Persayo loam, 1 to 20 percent slopes, eroded, and 40 percent is Chipeta silty clay loam, 3 to 20 percent slopes, eroded. These soils are intermingled and occur in no identifiable pattern. The Chipeta soil generally is on ridges and has stronger slopes than the Persayo soil.

Included in the mapping were areas of 1 to 5 acres made up of a very strongly saline soil and of areas of a moderately deep soil. Also included was an area of about 200 acres, 5 miles east of Castle Dale, of a brown soil that is similar to the Persayo component mapped in this unit.

The Persayo soil has the profile described as typical of the series. It is well drained and has moderate permeability. Roots penetrate to the shale, and then they spread horizontally. This soil holds 1 to 3 inches of available water, the amount depending on the depth to bedrock. Runoff is medium, and the susceptibility to erosion is moderate.

The Chipeta soil has a profile similar to the one described as typical for the Chipeta series, except that the slopes are stronger and it is eroded. Rill and gully erosion are active.

The soils in this mapping unit are used mainly for spring and fall range, but in places they are used for irrigated pasture. Sheet erosion is active, and in many places shallow gullies have cut into the shale bedrock. (The Persayo soil is in capability unit VIIe-D4, nonirrigated; Desert Loamy Shale range site. The Chipeta soil is in capability unit VIIe-D3, nonirrigated; Desert Shale range site)

# RAVOLA SERIES

The Ravola series consists of very deep, well drained soils that formed in alluvium derived from shale, siltstone, and sandstone. Ravola soils are on alluvial fans and flood plains. Slopes range from 0 to 10 percent. Mean annual precipitation is about 7 inches and the mean annual temperature is about 50 degrees F.

**TAXONOMIC CLASS:** Fine-silty, mixed, active, calcareous, mesic Typic Torrifluvents

**TYPICAL PEDON:** Ravola loam under cultivation. (Colors are for dry soil unless otherwise noted.)

**Ap1**--0 to 6 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak coarse subangular blocky structure parting to weak fine subangular blocky; slightly hard, friable, slightly plastic; many fine roots, few coarse roots; common fine and medium pores; strongly effervescent; slightly alkaline (pH 7.8); clear smooth boundary. (2 to 6 inches thick)

**Ap2**--6 to 9 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; strongly compacted plowpan layer; weak coarse subangular blocky structure parting to weak coarse granular; hard, friable, slightly sticky and slightly plastic; many fine roots; common fine pores; few medium pores; strongly effervescent; slightly alkaline (pH 7.7); clear smooth boundary. (0 to 3 inches thick).

**C1**--9 to 18 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak thin platy structure parting to weak very thin platy; hard, friable, slightly sticky and slightly plastic; few coarse and many fine roots; many medium and common fine pores, strongly effervescent; slightly alkaline (pH 7.7); gradual wavy boundary. (9 to 24 inches thick)

**C2**--18 to 45 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; weak coarse subangular blocky structure parting to weak medium granular; slightly hard, friable, slightly sticky and slightly plastic; few medium and many fine roots; common medium pores; strongly effervescent; moderately alkaline (pH 7.9); gradual irregular boundary. (6 to 30 inches thick)

**C3**--45 to 60 inches; light brownish gray (2.5Y 6/2) loam, dark grayish brown (2.5Y 4/2) moist; massive; soft, very friable; few fine roots; few fine pores; strongly effervescent; moderately alkaline (pH 7.9).

**TYPE LOCATION:** Emery County, Utah; about 1 1/2 miles south and 1/2 mile east of Huntington; located about 2,000 feet west and 600 feet north of the southeast corner of sec. 31, T. 17 S., R. 9 E.

**RANGE IN CHARACTERISTICS:**

Mean annual soil temperature: 49 to 56 degrees F

Particle-size control section: 18 to 27 percent clay and less than 15 percent sand coarser than very fine sand

A horizon:

Hue: 10YR to 5Y

Value: 5 to 7 dry, 4 or 5 moist

Chroma: 2 or 4 dry or moist

Texture: loam, clay loam, very fine sandy loam, or silt loam

Calcium carbonate equivalent: 5 to 25 percent

Reaction: slightly to strongly alkaline

C horizon:

Hue: 10YR to 5Y

Value: 5 to 7 dry, 4 or 5 moist

Chroma: 2 to 4 dry or moist

Texture: stratified loamy sand to clay loam

Calcium carbonate equivalent: 5 to 25 percent

Reaction: slightly to strongly alkaline

**GEOGRAPHIC SETTING:**

Parent material: alluvium derived from shale, siltstone, and sandstone

Landform: alluvial fans and flood plains

Slopes: 0 to 10 percent

Elevation: 4,500 to 6,000 feet

Mean annual temperature: 47 to 56 degrees F

Mean annual precipitation: 5 to 11 inches

Frost-free period: 110 to 160 days

**DRAINAGE AND PERMEABILITY:** well drained, negligible to medium runoff, moderate or moderately slow permeability. These soils are subject to occasional brief flooding following high intensity summer thunderstorms.

**USE AND VEGETATION:** Irrigated areas are used for growing small grains, corn, sugar beets, alfalfa, and pasture. Potential vegetation is shadscale, greasewood, Indian ricegrass, and galleta.

**DISTRIBUTION AND EXTENT:** Eastern Utah, northwest New Mexico and western Colorado. LRR D, MLRA 28A, 34, 35, 37. This series is of large extent.

**REMARKS:** Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon: The zone from 0 to 9 inches. (Ap1 and Ap2)

**RAVOLA LOAM, 1 TO 3 PERCENT SLOPES (R1B):** In most places the profile of this soil is like the one described as typical of the series. In some places, however, the texture between depths of 10 and 40 inches is silt loam to very fine sandy loam and the texture below 40 inches is

sandy loam to silty clay loam. Salinity generally is slight to moderate. Alkalinity ranges from none to moderate. Veins of gypsum are common below a depth of 20 to 30 inches. The frost-free season is 110 to 130 days in 3 out of 4 years.

Included in mapping were areas of Billings silty clay loam, and other areas ½ acre to 1 acre in extent, of poorly drained, strongly or very strongly saline-alkali soils. Also included were areas of a soil that is brown or light olive in color, and areas of Ravola loam in which the slopes are slightly less than 1 percent.

Drainage is good, and permeability is moderate. Runoff is medium, and the susceptibility to erosion is moderate. Roots penetrate to a depth of 5 feet or more. This soil retains about 10.5 inches of water, but only about 6 inches of water is readily available to plants. Natural fertility is low, but the fertility in many fields is high because fertilizer has been applied. This soil is easy to work and to irrigate. The uniform distribution of irrigation water is needed. Land leveling can be done with little or no damage to the soil.

This soil is used for spring and fall range and for irrigated pasture, alfalfa, small grains, corn, and sugar beets. The growing season is long enough for alfalfa to produce two full cuttings and part of a third. Corn does not mature for grain and is used for ensilage. (Capability units IIe-2, irrigated and VIIc-D, nonirrigated; Desert Loam Bottom range site)

# SANPETE SERIES

The Sanpete series consists of very deep, well to somewhat excessively drained, moderately rapidly permeable soils that formed in alluvium dominantly from limestone, sandstone, and shale. Sanpete soils are on alluvial fans and alluvial plains and have slopes of 1 to 30 percent. The average annual precipitation is about 11 inches and the mean annual air temperature is about 48 degrees F.

**TAXONOMIC CLASS:** Loamy-skeletal, carbonatic, mesic Xeric Haplocalcids

**TYPICAL PEDON:** Sanpete gravelly fine sandy loam--rangeland. (Colors are for air-dry soil unless otherwise stated.)

**A1**--0 to 3 inches; pale brown (10YR 6/3) gravelly fine sandy loam, brown (10YR 4/3) moist; weak thin platy structure; soft, very friable, nonsticky and slightly plastic; few fine roots; common very fine pores; 30 percent coarse fragments, dominantly gravel; strongly effervescent; carbonates are disseminated; moderately alkaline (pH 8.4); abrupt smooth boundary. (2 to 3 inches thick)

**A2**--3 to 11 inches; very pale brown (7.5YR 6/3) gravelly loam, brown (7.5YR 5/3) moist; weak medium subangular blocky structure; soft, very friable, slightly sticky and slightly plastic; many fine roots; common very fine and few fine pores; 18 percent coarse fragments, dominantly gravel; strongly effervescent, carbonates are disseminated; moderately alkaline (pH 8.2); clear wavy boundary. (5 to 12 inches thick)

**Bk1**--11 to 17 inches; very pale brown (10YR 7/3) very gravelly sandy loam, light brown (7.5YR 6/3) moist; massive; soft, very friable, slightly sticky and slightly plastic; many fine roots; common very fine pores; 50 percent coarse fragments, dominantly gravel; violently effervescent, carbonates are disseminated and coated on the rock fragments and accumulated in soft rounded accretions; moderately alkaline (pH 8.3); clear wavy boundary. (9 to 16 inches thick)

**Bk2**--17 to 48 inches; light brown (7.5YR 6/3) extremely gravelly sandy loam, brown (7.5YR 5/3) moist; massive; soft, very friable, slightly sticky and slightly plastic; many fine roots; common very fine pores; 65 percent coarse fragments, dominantly gravel; violently effervescent, carbonates are disseminated and coated on the rock fragments and accumulated in soft rounded accretions; moderately alkaline (pH 8.3); clear wavy boundary. (11 to 28 inches thick)

**C**--48 to 60 inches; light brown (7.5YR 6/3) very gravelly sandy loam, brown (7.5YR 4/4) moist; massive; soft, very friable, nonsticky and slightly plastic; few very fine roots; common very fine pores; 45 percent gravel, 10 percent cobbles; strongly effervescent, carbonates are disseminated; moderately alkaline (pH 8.4).

**TYPE LOCATION:** Sanpete County, Utah; 3 miles south and 5 miles west of Gunnison; 30 feet east of telephone pole on south side of road, about 412 feet north and 600 feet east of the southwest corner of Section 3, T. 20 S., R. 1 W.

**RANGE IN CHARACTERISTICS:** The mean annual soil temperature is 47 to 54 degrees F., the mean summer soil temperature is 64 to 68 degrees F. In more than 7 out of 10 years the soils are dry in the moisture control section for 60 to 80 consecutive days between June 21 and September 21, and are dry in the moisture control section 50 to 60 percent of the time the soil temperature at 20 inches is above 41 degrees F. in most years, and are moist for 60 to 75 consecutive days during the 120 days after the winter solstice.

The particle-size control section ranges from 10 to 27 percent clay. Coarse fragments in the particle-size control section range from 35 to 80 percent and range from gravel to stones. Depth to the calcic horizon ranges from 4 to 15 inches. The calcium carbonate equivalent content of the 10 to 40 inch control section averages more than 40 percent including the lime in the coarse fragments less than 20 millimeter in diameter.

The A horizon has hue of 10YR or 7.5YR, value of 5 to 7 dry 4 or 5 moist, and chroma of 2 to 4. It is moderately to strongly alkaline.

The Bk horizon has hue of 10YR, 7.5YR or 5YR, value of 6 to 8 dry, 4 to 6 moist, and chroma of 2 to 6 dry or moist. It is loam, silt loam or sandy loam, with 35 to 80 percent coarse fragments. It is moderately to strongly alkaline. Calcium carbonate equivalent is 40 to 70 percent. SAR ranges from 0 to 25 and gypsum content is 0 to 2 percent.

The C horizon has hue of 10YR, 7.5YR or 5YR, value of 6 or 7 dry, 4 to 6 moist and chroma of 2 to 4. It is a loam, sandy loam or sand with 25 to 80 percent rock fragments. This horizon is moderately alkaline or strongly alkaline. Calcium carbonate equivalent is 40 to 70 percent. SAR ranges from 0 to 25 and gypsum content is 0 to 2 percent.

**GEOGRAPHICAL SETTING:** Sanpete soils occur on alluvial fans, alluvial flats and foothills. Slope range is 1 to 30 percent. These soils formed in alluvium from limestone, sandstone, shale, and igneous rock. These soils occur at elevations of 5,000 to 6,600 feet. The climate is semiarid to dry subhumid with a mean annual air temperature of about 45 to 52 degrees F., mean summer temperature of about 64 to 68 degrees F. and average annual precipitation is about 8 to 12 inches. The freeze-free period ranges from 100 to 140 days.

**DRAINAGE AND PERMEABILITY:** Well to somewhat excessively drained; medium to rapid runoff; moderate and moderately rapid permeability.

**USE AND VEGETATION:** These soils are used mainly for rangeland and for irrigated crops of alfalfa, small grains and pasture. The principal vegetation is Indian ricegrass, needleandthread grass, winterfat, bud sage, black sagebrush, and shadscale.

**DISTRIBUTION AND EXTENT:** Central and northern Utah. MLRA 28A. This series is moderately extensive.



**REMARKS:** Diagnostic horizons and features recognized in this pedon are:

Ochric epipedon - the zone from the surface of the soil to 11 inches (A1 and A2 horizon).

Calcic horizon - the zone from 11 to 48 inches (Bk1 and Bk2 horizons).

Xeric feature - soil moisture regime is Aridic bordering Xeric.

Particle-size control section - the zone from 10 to 40 inches.

This soil was reclassified from a Xerollic Calciorthids to a Xeric Haplocalcids on 9/94.

**SANPETE SANDY CLAY LOAM, 1 TO 3 PERCENT SLOPES (SIB):** The profile of this soil is the one described as representative of the series. Typically, gravel is in the upper 10 inches, and in places gravel is on the surface. Near the mountains on the upper parts of benches, the coarse fragments typically range from 3 to 20 inches in diameter. On the lower ends of the benches, 3 or 4 miles away from the mountains, the coarse fragments typically range from 1½ to 10 inches in diameter.

Drainage is good, and permeability is rapid. Root penetration is restricted by gravel and cobblestones below a depth of about 20 inches. About 3.5 inches of water is retained in this soil, but only about 2 inches of water is readily available to plants. Runoff is medium, and the susceptibility to erosion is moderate. This soil is fairly hard to work. Leveling is difficult because of the cobblestones and gravel.

This soil is used for spring and fall range and for irrigated pasture, alfalfa, small grains, and corn. Because of the short growing season, alfalfa produces only two full crops and part of a third in a year. Erosion is reduced if this soil is used for hay or pasture most of the time. Alfalfa responds well to applications of a phosphate fertilizer. (Capability units IVs-24, irrigated, and VIIs-S4, nonirrigated; Semi-Desert Limy Loam range site)

Consolidation Coal Company  
Emery Mine

Federal Lease Incidental Boundary Change  
September 12, 2006

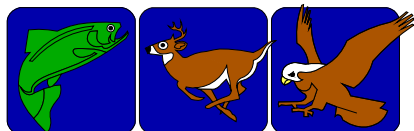
## **APPENDIX XIII-2**

### Vegetation and Wildlife Report

**VEGETATION & WILDLIFE**  
*of the*  
**FEDERAL LEASE IBC AREA**

*at the*  
**EMERY MINE SITE**

*for*  
**CONSOL ENERGY**



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September 2006



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# **VEGETATION & WILDLIFE** *of the* **FEDERAL LEASE IBC AREA**

## **INTRODUCTION**

Consolidation Coal Company (Consol) has applied for an Incidental Boundary Change (IBC) to the Emery Mine permit area. The new area has been called Federal Lease IBC Area and is approximately 160 acres in size and is located north of the 4<sup>th</sup> East Portal site.

No surface disturbance has been planned for the new area. Moreover, subsidence caused by underground mining is also not anticipated during this phase of the mining operations. Therefore, there should be no change to the ground surface or the existing plant communities in the Federal Lease IBC Area as a result of the proposed mining activities.

The major plant communities of the Federal Lease IBC Area have been mapped (see attached *Vegetation Map of the Federal Lease IBC Area* ). A wildlife habitat map has also been prepared (see attached *Wildlife Habitat Map of the Federal Lease IBC Area* ). A discussion about the plant communities and big game wildlife species as well as the potential for the occurrence of threatened or endangered species have also been included in this document.

## METHODS

The vegetation of the Federal Lease IBC Area was mapped in the field by walking the area and by using aerial photography. The field work was conducted July 6, 2006.

Species of concern by the State of Utah, Division of Wildlife Resources (DWR) were reviewed in the state's GIS database system. Potential threatened and endangered species lists were compiled after consulting previously with the U.S. Fish & Wildlife Service, Salt Lake City, Utah and files located at *Mt. Nebo Scientific, Inc.*, Springville, Utah.

## RESULTS

### VEGETATION

Beginning at the higher elevations and moving downward, there were 3 major plant community types in the Federal Lease IBC Area including: Shadscale/Winterfat, Greasewood and Pasture Lands. These communities are shown on the vegetation map included with this report. A brief description of each of these communities follows below; color photographs of each community type have also been included in this report.

### **Shadscale/Winterfat**

A Shadscale/Winterfat plant community occupied a small percentage of the plant communities in the Federal Lease IBC Area. It was located in an isolated area near one corner of the study area (see Vegetation Map and Photo 1). As the community name suggests, this community was dominated by shadscale (*Atriplex confertifolia*) and winterfat (*Ceratoides lanata*).

### **Greasewood**

Greasewood communities can be found as the elevation decreases. This community occupies the largest portion of the study area (see Vegetation Map and Photos 2,3). This community is known for its relatively low species diversity with the dominant plant species comprised of greasewood (*Sarcobatus vermiculatus*) and Torrey's seepweed (*Suaeda torreyana*).

Some of this native plant community has been disturbed by cultivation and conversion to pasture land. There were often "weedy" or exotic species such as halogeton (*Halogeton glomeratus*) and Western stickseed (*Lappula occidentalis*) present in these areas.

### **Pasture Land**

Some of the lower elevation areas have been converted to pasture land. A portion of the pasture lands are currently irrigated (see Photo 4); others had been irrigated in the past and



are currently dry (see Photos 5, 6). This differentiation was also delineated on the vegetation map included in this report.

The lowest elevation areas were the natural drainages in the study area. Some of these areas (see Photo 7) were dominated by saltgrass (*Distichlis strictus*). Undoubtedly in the past, prior to the flood irrigation techniques presently being used in the area, there were many more areas dominated by saltgrass. With the increase in water from irrigation runoff, some isolated areas that were once dominated by saltgrass, have been converted and support more hydrophilic plant species as dominates such as willow (*Salix exigua*), sedges (*Carex* spp.), rushes (*Juncus* spp.) and spikerushes (*Eleocharis* spp.). Some of these distinctions are shown in the color photographs included in this report (see Photo 8).

### Threatened and Endangered Species

There are several federally listed plant species that are known to occur in Emery County, Utah (Table 1). However, there is almost no chance of these species occurring directly in the study area. Because it was late in the

Table 1: Potential Threatened or Endangered Plant Species of the Federal Lease IBC Area at the Emery Mine		
Scientific Name	Common Name	Status
<i>Pediocactus winkleri</i>	Winkler Footcactus	T
<i>Pediocactus despainii</i>	Despain Footcactus	E
<i>Schoenocrambe barnebyi</i>	Barneby's schoenocrambe	E
<i>Sclerocactus wrightiae</i>	Wright Fishhook Cactus	E
<i>Townsendia aprica</i>	Last Chance Townsendia	T
<i>Erigeron maguirei</i>	Maguire Daisy	T
<i>Cycladenia humilis</i> var. <i>jonesii</i>	Jones Cycladenia	T
E = Federal Protection, Endangered T = Federal Protection, Threatened		

flowering season for some of the target species, the field work conducted on the site was done to assess the habitats as well as to search for sensitive species in the study area. If the species were not visually observed, assessment of the habitat provided clues to the probability of one of these species existing at each site.

No threatened or endangered plant species were found within the boundaries of the study area. Additionally, the habitat assessment suggested a very low probability (or almost no chance) that any of these species could occur at the sites. Finally, if any sensitive species were to exist in the area, they would not be impacted by the underground mining activities (no surface disturbance has been planned in the study area).

## WILDLIFE

Geographical database information from the State of Utah, Division of Wildlife Resources (DWR) suggest the area is not critical habitat for pronghorn, elk, mule deer, sage grouse, or rocky mountain bighorn sheep. The database does, however, suggest the study area to be “High Value Winter Habitat” for elk (see attached *Wildlife Habitat Map of the Federal Lease IBC Area*).

### **Raptors**

In 2001 DWR biologists visited the site along with representatives from Consolidation Coal Company. At that meeting it was suggested that there was a low probability of raptor occurrence in the area (refer to: *Biological Impacts at the 4<sup>th</sup> East Portal Area at the Emery Deep Mine*. 2002. Mt. Nebo Scientific. Springville, UT). Since that time Consolidation Coal Company has participated in the annual raptor surveys conducted by DWR and other coal mine operators in the area.

In addition, during site visits by *Mt. Nebo Scientific, Inc.* surveys were conducted for major prairie dog communities in the study area. Prairie dog communities are known to be important habitat for burrowing owls (*Athene cunicularia*). One such community was located previously and is shown on a map in the Emery Mine’s Mining & Reclamation Plan [Selected

Wildlife Information (Plate 10-1)]. Because no surface disturbance that could impact this community is expected within the boundaries of the Federal Lease IBC Area, it has not been studied for either prairie dogs or burrowing owls.

### Threatened and Endangered Species

There are also several federally listed animal species that are known to occur in Emery County, Utah (Table 2). However, there is almost no chance of these species occurring directly in the study area for lack of habitat.

<b>Table 2: Potential Threatened or Endangered Animal Species of the Federal Lease IBC Area at the Emery Mine</b>		
<b>Scientific Name</b>	<b>Common Name</b>	<b>Status</b>
<i>Gilia elegans</i>	Bonytail	E
<i>Ptychocheilus lucius</i>	Colorado Pike minnow	E
<i>Gila cypha</i>	Humpback Chub	E
<i>Xyrauchen texanus</i>	Razorback Sucker	E
<i>Haliaeetus leucocephalus</i>	Bald Eagle	T
<i>Strix occidentalis lucida</i>	Mexican Spotted Owl	T
<i>Mustela nigripes</i>	Black-footed Ferret	E
<i>Empidonax traillii extimus</i>	Southwestern Willow Flycatcher	E
<i>Coccyzus americanus occidentalis</i>	Western Yellow-billed Cuckoo	C
<i>E</i> = Federal Protection, Endangered <i>T</i> = Federal Protection, Threatened <i>C</i> = Candidate		

COLOR PHOTOGRAPHS  
of the  
PLANT COMMUNITIES





Photo 1: Shadscale/Winterfat Community



Photo 2: Greasewood Community





Photo 3: Greasewood Community



Photo 4: Pasture Land (Irrigated)





Photo 5: Pasture Land (Dry)



Photo 6: Pasture Land (Dry)



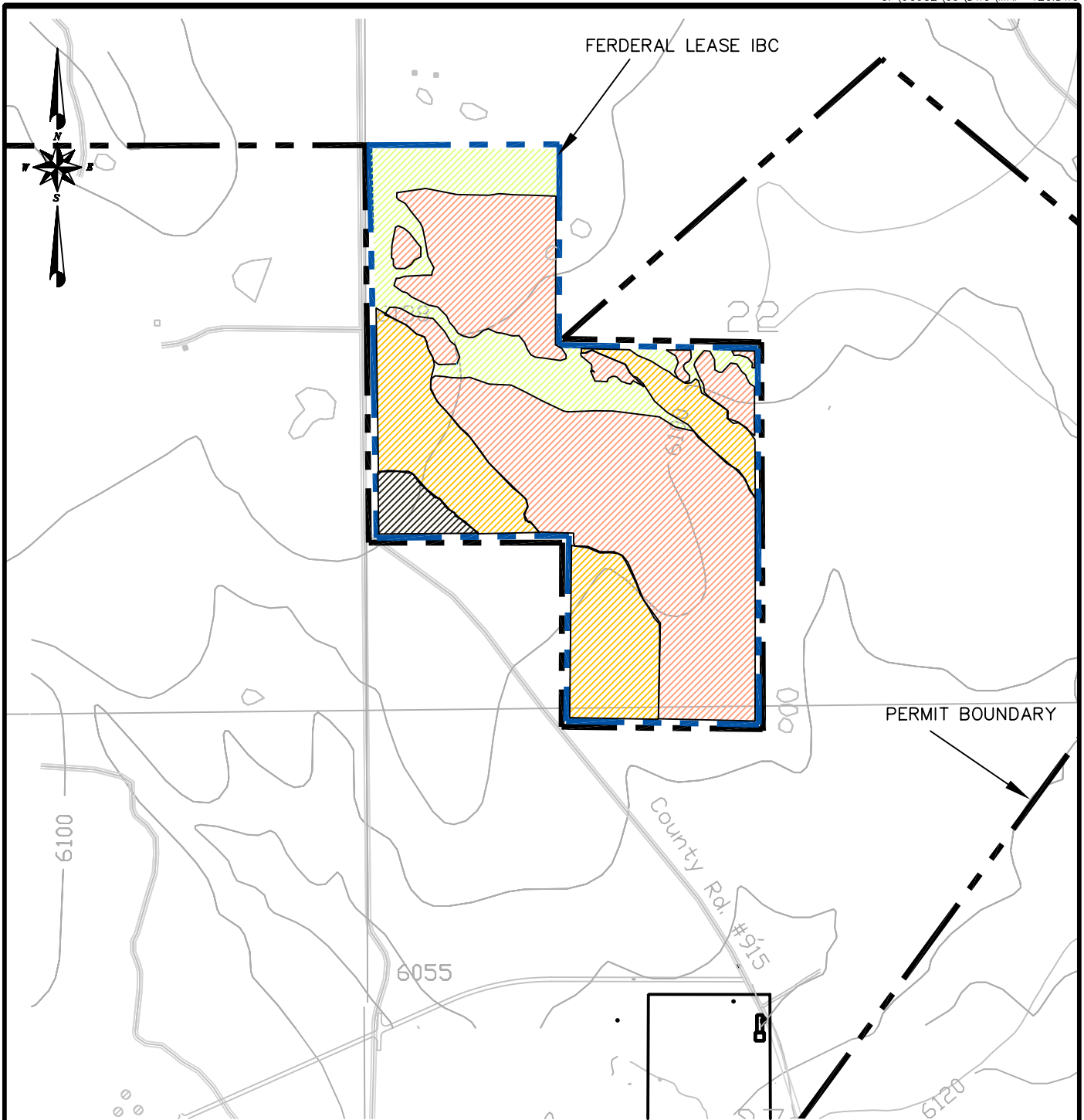


Photo 7: Pasture Land (Saltgrass Area)



Photo 8: Pasture Land (Willows, Sedges, Rushes, Saltgrass Areas)

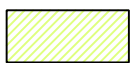
VEGETATION & WILDLIFE MAPS  
of the  
FEDERAL LEASE IBC AREA



# LEGEND



GREASEWOOD



PASTURE LAND (DRY)



PASTURE LAND (IRRIGATED)

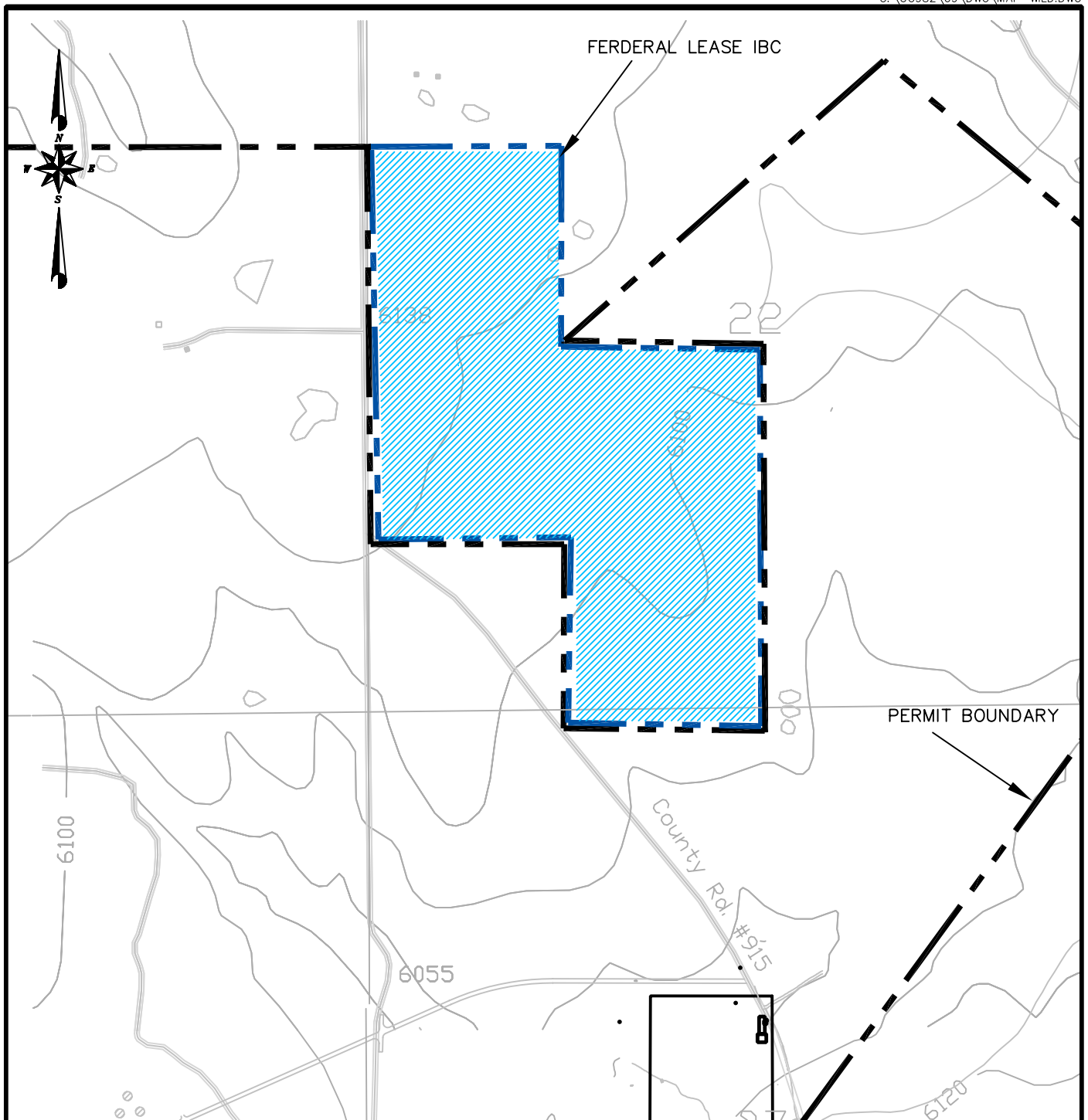


SHADSCALE/WINTERFAT

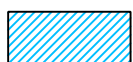


## VEGETATION MAP OF THE FEDERAL LEASE IBC AREA





# LEGEND



ROCKY MOUNTAIN ELK (HIGH VALUE WINTER HABIITAT)



FEDERAL LEASE BOUNDARY



PERMIT BOUNDARY



## WILDLIFE HABITAT MAP OF THE FEDERAL LEASE IBC AREA